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Paper 101

Aggregate Resources Inventory of Sullivan Township

Grey County
Southern Onta

By Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

1985

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Minister
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Aggregate Resources Inventory of Sullivan Township Grey County

by
Staff[1] of the Engineering and Terrain Geology Section

1. Project supervisor: Dale W. Scott; field work and report by D. Tennant; compilation and drafting by staff of the Aggregate Assessment Office. The Mineral Resources Staff of Owen Sound District and Southwestern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

This report includes both an inventory and evaluation of sand and gravel, as well as bedrock resources, in Sullivan Township. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Pits and Quarries Control Act.

Three areas containing good-quality outwash sand and gravel have been selected for possible resource protection at the primary level. These areas constitute the most important natural aggregate sources in Sullivan Township and cover 3300 acres (1340 ha), of which 2500 acres (1010 ha) are considered to be available for extraction. Possible resources are estimated to be 93 million tons (84 million tonnes). The available portions of the selected areas represent 16 percent of the total area of sand and gravel deposits in the township and 19 percent of the original tonnage.

In addition, several ice-contact gravel and sand deposits have been selected as Sand and Gravel Resource Areas of Secondary Significance. Although these secondary, and the remaining tertiary deposits, are not considered the "best" resources, they should be considered part of the township's aggregate supply.

Dolostone of the Guelph Formation underlies most of the township, while shale of the Salina Formation underlies the extreme southwest corner. A relatively large portion of the township is overlain by less than 50 feet (15 m) of drift. Although the Guelph Formation is a valuable source of dolomitic lime, neither the Salina nor the Guelph Formations are suitable for the production of road-building or construction aggregate. Consequently, no bedrock areas were selected.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

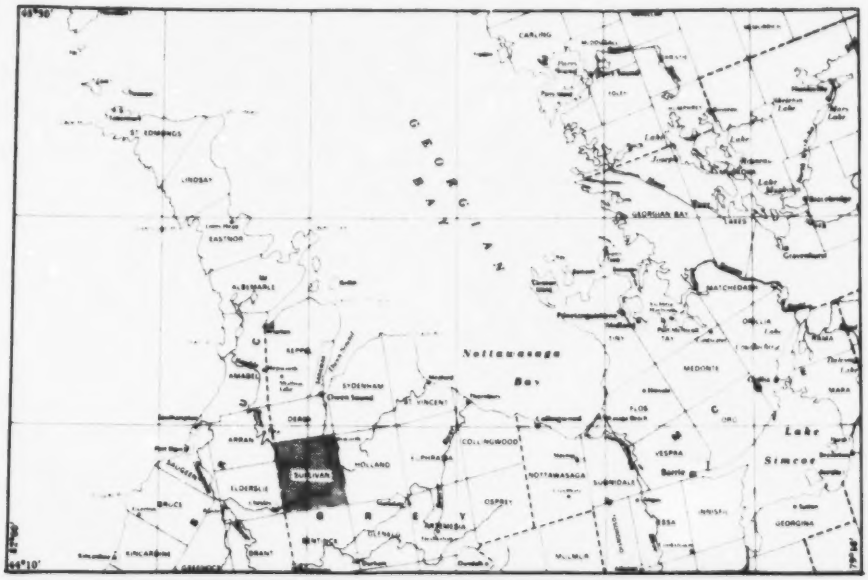


Figure 1. Key Map Showing the Location of Sullivan Township, Scale 1:1 800 000

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregates extracted was 101 million tons (92 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1983).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential of bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing, hand augering and geophysical techniques are used to assess subsurface materials. Airphotos at various scales are used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100- pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution and in some cases Los Angeles abrasion, absorption, and Magnesium Sulphate soundness tests along with petrographic analyses are performed.

Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey. In areas of limited subsurface exposure, test holes are drilled and geophysical surveys using hammer seismic equipment are undertaken. The symbols for and locations of sample and test hole sites along with geophysical traverse lines are noted on Map 1.

In the office, the field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps, and from the interpretation of water well records. The

measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tons of a one-foot (0. 3 m) thick section of rock, one acre (0.4 ha) in extent).

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg per cubic metre) or 3600 tons per acre (8070 tonnes per hectare). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

Part II — Data Presentation and Interpretation

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

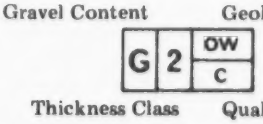
Map 1 is derived from existing surficial geology maps of the area or from airphoto interpretation in areas where surficial mapping is incomplete. The map shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The information from which these symbols are derived has been plotted in grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol. Geophysics lines are shown on the map by a line symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by dark shading on Map 2.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light red shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Al-

though deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the litholgy of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes, pits or sample sites have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on ex-

tractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalites with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three shades of blue. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas consitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource ares. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected drill hole which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approch. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Part III — Assessment of Aggregate Resources in Sullivan Township

LOCATION AND POPULATION

Sullivan Township occupies approximately 75,901 acres (30 717 ha) in the northern portion of Grey County, southern Ontario. The township is shown on the Chesley (41 A/6) and the Markdale (41 A/7) map sheets of the National Topographic System, at a scale of 1:50 000.

The population of the township has risen from 2060 in 1972 to 2263 in 1982, for a total increase of approximately 10 percent (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The township supports mainly farming activities.

There are no major urban centres located within Sullivan Township. However, the City of Owen Sound, located north of the township on King's Highway 6, serves as a commercial, industrial and institutional centre on a regional level. Since the 1940s, Owen Sound's population has only shown a minor increase (Owen Sound Planning Board 1976). The total population of the city in 1982 was 19 624 (Ontario Ministry of Municipal Affairs and Housing 1983).

The Towns of Durham (Grey County) and Chesley (Elderslie Township, Bruce County), and the Villages of Chatsworth and Tara (Arran Township, Bruce County) provide local services at various levels to the mostly rural population of Sullivan Township, as do Sullivan's own hamlets of Desboro, Mooresburg, and Williamsford. Most of these communities have shown small growth rates of 1 to 8 percent from 1972 to 1982 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974).

Access to the township is provided by King's Highway 6 which forms its eastern boundary. Various county and township roads provide connecting links within the township.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography of Sullivan Township has been discussed in a broad, regional sense by Chapman and Putnam (1966) and in detail by Feenstra (in prep.). Some of the moraine terminology used in this report is based on the reclassification of the Port Huron Moraine System by Feenstra (1975) and Sharpe (1975), in which portions of the Singhampton Moraine (Chapman and Putnam 1966) were renamed the Gibraltar Moraine. The following discussion is based primarily on the findings of these authors.

Approximately 23 000 years ago, during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"), lobes or submasses of the Laurentide continental ice sheet advanced out of the basins of the Great Lakes and joined together to cover southern Ontario. The lateral extent of the ice lobes and the positions of their margins underwent numerous fluctuations until approximately 10 000 years ago when the ice melted back and completely disappeared. The physiography and distribution of surficial materials in Sullivan Township, and specifically the sand and gravel deposits shown on Map 1 of this report, are the result of the activities of the Georgian Bay ice lobe during the Late Wisconsinan Substage.

A strong advance of the Georgian Bay ice lobe formed a landscape of drumlinized ground moraine in Sullivan Township. Most of the ground moraine is made up of Elma Till and Catfish Creek Till which is unsuitable for use as aggregate because it contains excessive amounts of fine-grained material. Superimposed on the ground moraine are large areas of outwash, end moraines, kames, eskers, ice-contact deltas, and lake plains, formed during the subsequent melting of the ice lobe. This landscape can be divided into three physiographic regions: the Horseshoe Moraines (Chapman and Putnam 1966; Feenstra 1975; Sharpe 1975) in central and southern Sullivan; the Saugeen Clay Plain (Chapman and Putnam 1966) in western Sullivan; and the Arran Drumlin Field (Chapman and Putnam 1966) in northern Sullivan.

Parts of the Horseshoe Moraines cover most of southern and southeastern Sullivan Township. Three end moraines are located in this area of the township: the Gibraltar Moraine; the Banks Moraine; and the Williscroft Moraine. These moraines delineate the positions of the ice fronts as they melted back through Sullivan Township. The Gibraltar Moraine arcs across the extreme southeastern corner of the township, from south of Williamsford to south of Kinghurst. The moraine, consisting of outwash and dissected ice-contact stratified drift, contains varying amounts of sand and gravel, and is characterized by a hummocky topography (Feenstra, in prep.).

Located north and west of the Gibraltar Moraine, the Banks Moraine runs roughly parallel to, and north of, the North Saugeen River from the west side of Sullivan Township to north of Mooresburg, where it turns north to the Brotske Lake-Stewart Lakes area, and then east to cross over the township boundary just north of Williamsford. For most of its length, the moraine is narrower than the Gibraltar Moraine and is either formed from till or capped by up to 14 feet (4 m) of till (Feenstra, in prep.). In the Brotske Lake-Stewart Lakes area, a re-entrant separated two sublobes of the Georgian Bay ice lobe. Investigations show that here the moraine consists of ice- contact stratified drift partially till capped (Feenstra, in prep.). The till of the Banks Moraine is gravelly with a variable matrix.

Outwash sand and gravel deposits are located between the Banks and Gibraltar Moraines. Feenstra (in prep.) has discussed several possible modes of origin such as: 1) the outwash was deposited by meltwaters associated with the melting of the ice from the Gibraltar Moraine position to the Banks Moraine position; 2) by meltwaters associated with the sublobate re-entrant in the area east of Desboro; 3) by later meltwater streams which entered the area from the east; or, 4) by any combination of the above. These deposits are the most important sources of high-quality aggregate in Sullivan Township.

The Banks Moraine is paralleled on its north side by the Williscroft Moraine. This moraine is the first

of a series of smaller end moraines called the Tara Moraines (Sharpe and Edwards 1979). The Williscroft Moraine consists of one or two small, rounded crests made up of a silt to sandy silt till and, in places, capped by glaciolacustrine silt and clay deposits. The Williscroft Moraine, and the other Tara Moraines, were formed during halts or very minor fluctuations of the melting ice margin. The Tara Moraines run east- west and often form connecting till ridges between the long narrow drumlins of the Arran Drumlin Field, located in northern Sullivan Township. The moraines contain limited amounts of sand and gravel.

During the formation of the Tara Moraines, meltwaters ponded into short-lived, proglacial lakes in the area surrounded by the Banks Moraine to the south, and the Sydenham River to the east. The fine- grained glaciolacustrine deposits found capping parts of the Banks and the Tara Moraines were deposited in these lakes.

Several esker systems were also active during deglaciation. In places, where the esker material entered the proglacial lakes, ice- marginal deltas were formed. Several esker-delta complexes exist in northern Sullivan Township. These complexes contain limited to moderate amounts of aggregate.

EXTRACTIVE ACTIVITY

In 1975, Sullivan Township was designated under the Pits and Quarries Control Act. Prior to that time, numerous small pits had been active in the township. Seventy-five pits (for which information is available) have been identified in this report, and are shown on Maps 1 and 2. Most of these pits are now inactive (abandoned). The Ontario Ministry of Transportation and Communications (M.T.C.) has rated twenty of these pits. Nine are considered to be moderate to moderate-high quality aggregate sources, indicating that they are capable of producing crushed aggregate for use in Granular Base Course (G.B.C.) A, and in some cases for Hot- Laid (H.L.) 4 stone. The remaining eleven pits were rated as being low to moderate sources capable of producing G.B.C. B and C in large quantity, and in some cases G.B.C. A (Deike 1982).

Ten of the identified pits in Sullivan Township are licenced for extraction under the Pits and Quarries Control Act. The total area of these licenced properties is 590.3 acres (238.9 ha). Between 1976 and 1982, the average annual licenced production was 52,500 tons (47 600 tonnes). Average annual wayside production for the same period of time was 97,100 tons (88 100 tonnes). Wayside pits are temporary pits opened and used by a public road authority solely for the purpose of a particular project or contract of road construction. During the 1976 to 1982 period, the amount of aggregate produced from licenced pits has steadily increased, while production from wayside pits has declined.

Selected Sand and Gravel Resource Areas

Sullivan Township contains approximately 15,600 acres (6300 ha) of sand and gravel. The total estimated tonnage in these deposits is 500 million tons (455 million tonnes).

The best quality aggregate is generally found in the southern and eastern parts of the township. Three areas of outwash sand and gravel have been selected for possible resource protection at the primary level. Selected Resource Areas 1 to 3 cover approximately 3300 acres (1340 ha), exclusive of licenced properties. An estimated 2500 acres (1010 ha) are considered to be available for extraction, containing a total tonnage of 93 million tons (84 million tonnes). The available portions of the selected areas represent 16 percent of the total area of sand and gravel deposits in the township and 19 percent of the original tonnage.

Although their mode of origin varies, the deposits have a number of general quality and workability characteristics in common. The major constraint, which occurs in varying degrees throughout the township, is the presence of soft carbonate clasts. Some pits in the township contain from 3 to 15 percent soft, porous dolostone clasts derived from the underlying Guelph Formation (Deike 1982). Soft dolostone is an unacceptable component in hot-laid products and structural concrete.

Fines content greater than 10 percent has also been noted in some of the deposits in the area (Deike 1982). Without extensive processing, this amount of fines would render the material unacceptable for most construction products including G.B.C. A, B and C. In addition, many pits have been found to contain insufficient quantities of crushable-sized gravel (clasts greater than 26.5 mm) for the production of G.B.C. A, 16 mm crushed, or hot-mix products.

Clay or silt seams, as well as cemented or clay-coated gravels, have been found in several pits. Clay, silt, or cemented seams should be avoided during extraction, which slows down the operation and increases the cost of the final product. Depending on the extent of clay coating, these sections can be avoided or the material in them can be washed to remove the fines. Washing increases the cost of a product. In several low-lying areas, high water tables may also limit extraction.

Several ice-contact deposits have been designated for secondary resource protection. These secondary deposits serve as important alternate extraction sites and should be considered as part of the total aggregate supply.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is located between the Banks and Gibraltar Moraines, in the vicinity of McCullough Lake, in southeastern Sullivan. The selected area consists of four outwash gravel deposits. As a group, Selected Area 1 occupies approximately 2190 acres (890 ha), exclusive of the licenced property.

Selected Area 1a is the largest deposit in the Resource Area. Although there are no licenced pits in the deposit, it does contain seven unlicenced pits (pit nos. 45, 47 to 52). Face heights in these pits ranged from 3 to 12 feet (1 to 4 m). The available water well data indicates 19 feet (6 m) and 23 feet (7 m) of gravel and sand in the northern section of the deposit, while a well in the southern part shows only 8 feet (2 m) of gravel over clay. This may indicate that the deposit thins towards the south.

The percentage of gravel in the abandoned pits ranges from 30 to 65 percent, with the exception of pit 45 which contains 5 to 10 percent gravel. During field investigations, samples were taken from pits 47 and 48. Analysis of the sample from pit 47 showed that it contained approximately 63 percent gravel, 35 percent sand, and 2 percent fines. The sample from pit 48 contained 54 percent gravel, 45 percent sand, and 1 percent fines. The gradations of these samples are displayed in Figures 3a, 3b, 4a and 4b. Figure 3a shows that approximately 34 percent of the gravel fraction in the sample taken from pit 47 is larger than 26.5 mm in size, indicating that the sample contains crushable material. The material in the sample was suitable, in terms of gradation, for use in the production of G.B.C. B and C, and 16 mm Crushed Type A. The sample from pit 48 contained material suitable for G.B.C. B and C.

Figures 3b and 4b show that in terms of gradation both samples contained high-quality sand. Very little screening is required to produce most hot-laid sand products (including H.L. 1 or concrete sand) from either of these samples.

Resource Area 1b contains part of licenced pit 7. The face in this part of the pit is 15 to 20 feet (5 to 6 m) high and exposes 50 to 60 percent gravel. Additional data are unavailable for this deposit, however, it is probably similar to Area 1a.

There are three abandoned pits in Area 1c (pit nos. 54, 55 and 56) and one abandoned pit in Area 1d (pit no. 53). These four pits show face heights of 10 to 15 feet (3 to 5 m) and contain 25 to 70 percent gravel. Samples were taken from pits 54 and 55 during field investigations. The results of the analyses of these samples are shown on Figures 5a and 5b, and 4a and 4b, respectively. The sample from pit 54 contained 66 percent gravel, 33 percent sand, and 1 percent fines. As 37 percent of the gravel fraction was greater than 26.5 mm in size, the sample is considered to be crushable. The gradation characteristics of the sample (Figure 5a) indicate that it contains material suitable for use in the production of G.B.C. B and C. The sample from pit 55 contains only 29 percent gravel, 62 percent sand, and 9 percent fines. The material in this sample was only acceptable for the production of G.B.C. B and C because of a lack of gravel and an excessive amount of fine material. Blending would be required to produce hot-laid asphaltic products and concrete sand.

Although care should be taken in extrapolating the results of sample analysis to an entire deposit or area, it would appear that the true value of Resource Area 1 in terms of aggregate extraction may be in the production of high-specification hot-laid and construction sand. This conclusion is based on gradation data only and more sampling and analysis are necessary in order to prove this resource. Other tests, including petrography, soundness, absorption, and porosity and abrasion resistance would also be of value. As previously discussed, the presence of soft porous dolostone in some of the deposits in Sullivan Township is a problem and may occur in the outwash gravels of Selected Resource Area 1.

Selected Resource Area 1 has 1590 acres (640 ha) considered to be available for aggregate extraction. Based on an average thickness of 15 feet (5 m) of usable material, the deposits contain an estimated 59 million tons (54 million tonnes) of sand and gravel. The deposits are easily accessible by various county and township roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Three outwash sand deposits located in southwestern Sullivan make up Selected Resource Area 2. The combined area of the deposits is 920 acres (370 ha), exclusive of the licenced property.

Selected Resource Area 2 contains part of licenced pit 8. However, extraction has not taken place in the outwash section of the property and, consequently, the face height and percent gravel figures do not reflect the conditions in Area 2a. Abandoned pits 71 and 72 are located in the deposit and these pits contain 10 to 25 percent gravel and have face heights of 5 to 15 feet (1.5 to 5 m). A field sample taken from pit 72 contained 19 percent gravel, 80 percent sand, and 1 percent fines. The gradation of the sample indicates that the material was suitable for G.B.C. B and C (Figure 6a). Because the sample grades very clean (less than 2 percent fines), compaction of G.B.C. B and C products made from this sample could be a problem because of the lack of a binder. Examination of Figure 6b shows that, in terms of gradation, the material in the sample could be used as concrete sand without any processing.

Although Selected Resource Area 2a contains less coarse aggregate than Resource Area 1a, the gradation characteristics of the fine fraction of the sample taken from pit 72 indicate that the two resource areas may contain similar high-quality fine aggregate. Caution must be employed when extrapolating the characteristics of one sample to a whole deposit, however, the two resource areas have the same mode of origin and may have similar characteristics. As in the case of Resource Area 1, further testing of Resource Area 2a is advisable. As data are unavailable for Resource Area 2b, it is assumed to be similar to Resource Area 2a. A high water table may pose problems in terms of aggregate extraction in these two deposits.

Selected Resource Area 2 has 770 acres (310 ha) available for extraction. Based on an average thickness of 10 to 15 feet (3 to 5 m) of usable material, the deposits contain an estimated 28 million tons (25 million tonnes) of sand and gravel. The resource area is easily accessible from Grey County Roads 3 and 25, as well as various township roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 is a gravel outwash deposit located north of the Banks Moraine adjacent to King's Highway 6 in eastern Sullivan Township. Area 3 contains a total of 210 acres (85 ha).

The deposit contains three abandoned pits (pit nos. 39, 40 and 41). Pits 39 and 40 contain an estimated 5 to 10 percent gravel and have face heights of 5 to 10 feet (1.5 to 3 m). In pit 40, bedrock was found at the pit floor. Pit 41 had 7- to 15-foot (2 to 5 m) faces and contained 40 to 70 percent gravel. Data obtained from M.T.C. for this pit indicate that 25 to

40 percent of the gravel fraction is larger than 26.5 mm in size, making it a source of crushable material. Two to 8 percent of the gravel fraction is greater than 100 mm. The pit can produce select subgrade, G.B.C. A, B and C, 16 mm Crushed Type A and B, and H.L. 4 and 8 stone. Oversize material must be crushed to produce G.B.C. B and the sand grades dirty and coarse for use in hot-mix products.

Resource Area 3 contains coarse aggregate in the east and grades finer to the west, a result of the southwesterly flow of the glacial meltwaters in this area. Bedrock is also found close to the surface in the western section of the deposit. A water well drilled near pit 41 shows 40 feet (12 m) of boulder gravel. These facts allow for the deposit thickness estimate of approximately 15 feet (5 m). The deposit has an estimated 160 acres (65 ha) available for extraction and contains approximately 6 million tons (5 million tonnes) of sand and gravel. The deposit is accessible from King's Highway 6 and various township roads.

Sand and Gravel Resource Areas of Secondary Significance

A number of deposits of ice-contact origin have been selected as Resource Areas of Secondary Significance. Secondary areas do not contain the best aggregate in the township, however, they may contain large quantities of sand and gravel of lower quality. The secondary areas in a township can be used to supply low-specification aggregate for local use. In Sullivan Township, a number of the selected secondary areas would normally be considered to be possible primary prospects, however, they contain deleterious materials or have workability constraints which limit their value as aggregate sources.

Two ice-contact deposits located in north-central Sullivan have been selected as being of secondary significance. The ice-contact delta-esker complex comprising the two areas was deposited during the formation of the Tara Moraines. The deltaic deposit contains two licenced pits (pit nos. 1 and 2) which have face heights of 15 to 20 feet (5 to 6 m). At the time of field investigation, the face in licenced pit 1 showed inclined beds of coarse to fine sand and gravel grading into fine gravel and coarse to very fine sand to the west. The overall percentage of gravel in the face was estimated to be 30 to 50 percent. Data obtained from M.T.C. indicate that the material in the pit can be used for G.B.C. A, B and C, and 16 mm Crushed Type B with sand control. The data also indicate that the source is too variable for crushing, although there is some crushable material available. In some areas the material is too dirty for use in hot- laid aggregate (Deike 1982).

The faces in licenced pit 2 were extremely variable, as reflected by an overall estimated gravel percentage of 10 to 70 percent (Deike 1982). Silt, clay, and cemented layers up to 2 feet (60 cm) thick were observed. Data obtained from M.T.C. indicate that G.B.C. A, B and C products with high fines content can be produced from this pit, as can 16 mm Crushed Type B and H.L. 4 coarse aggregate with selection and sand control during extraction (Deike 198[illegible]). There are no data available on the esker deposit other than one water well showing 52 feet (16 m) of gravel overlying bedrock. However, the esker is probably capable of supplying similar types of aggregate products.

To the east of the ice-contact delta-esker complex just described, is a similar complex containing three deltas and three esker segments. A road cut through the most northerly esker segment exposes 9 feet (3 m) of fine gravel with a sandy matrix (Leyland 1979). Licenced pit 3 has a face height of 25 to 35 feet (8 to 11 m) and contains 20 to 50 percent gravel. The face showed inclined and contorted beds of partially sorted sand and gravel with some silty fine sand to silt seams. Many of the gravelly layers were partially clay coated. Pockets of till-like material, and the presence of minor amounts of shale, soft dolostone and chert, and cemented clasts, were noted. Data obtained from M.T.C. indicate the presence of 1 to 2 percent chert and cherty carbonates in the pit. G.B.C. A, B and C, 16 mm Crushed Type A and B, and H.L. 4 and 8 stone can be produced (Deike 1982).

Licenced pit 4 contains 30 to 60 percent gravel and showed inclined beds of partially sorted sand and gravel. Some clay coating of the gravel and coarse sand, minor cementation, and the presence of chert were also noted. According to M.T.C. data the pit can produce the same products as licenced pit 3. Analysis of a field sample from pit 4 revealed 61 percent gravel, 38 percent sand and 1 percent fines (Figure 2a). The gradation of the fine aggregate indicates that the material could be used to produce high-specification fine aggregate, with screening, although this is not indicated in the M.T.C. information. A high petrographic number (P.N.) can make properly graded aggregate unsuitable for use in high-specification products, and several high P.N.s (169 to 172) have been reported for material in the vicinity (Deike 1982).

The esker segment to the south of pit 4 rises approximately 30 feet (9 m) above the surrounding lacustrine silts. This segment contains a coarse gravel core which fines laterally and upwards into medium to fine sand and silt, and may contain appreciable amounts of siltstone (Leyland 1979). The esker joins a small delta which is expected to be of a similar nature to the delta containing pits 3 and 4. A third esker segment leads south from the delta and is similar to the second esker segment, but is partially buried by lacustrine silts.

The southernmost delta in the sequence contains three abandoned pits (pit nos. 19, 20 and 21). The pits contain 40 to 70 percent gravel and have face heights ranging from 3 to 40 feet (1 to 12 m). There was a considerable amount of subangular to subrounded coarse gravel and oversize material in pit 19, with the maximum size being approximately 2.5 feet (80 cm). Pit 20 was a small excavation which contained coarse and fine gravel with coarse sand. The face in pit 21 contained fine gravel with coarse gravel and coarse to medium-fine sand. A sample taken from the pit contained 62 percent gravel, 36 percent sand and 2 percent silt (Figure 3a).

The third secondary area is a small gravel kame located in northeastern Sullivan Township. Part of licenced pit 5 is located in the kame. The face height is 30 to 35 feet (9 to 11 m) and the pit contains 50 to 60 percent gravel. The face reveals coarse and fine

gravel and medium to fine sand with some coarse sand and silty fine sand. Porous dolostone was noted in the pit. A field sample taken from the pit contained 73 percent gravel, 26 percent sand, and 1 percent fines (Figure 2a). The aggregate in the sample was suitable for the production of G.B.C. B and C, 16 mm Crushed Type A, and H.L. 1, 2, 3, 4 and 8 sand, and concrete sand, with blending. Further testing is required in the deposit to establish its overall quality.

The fourth secondary area consists of two sections of the Banks Moraine which contain ice-contact stratified drift. These deposits in the east-central part of the township contain licenced pit 7 and abandoned pit 36. Pit 7 contains 20 to 60 percent gravel and has face heights of 5 to 20 feet (1.5 to 6 m). The material found in the pit is poorly sorted, poorly stratified gravel, sand and silt. The pit is rated by M.T.C. as being able to produce 16 mm Crushed Type B. Pit 36 contains 20 to 50 percent gravel and has a face height of 5 to 15 feet (1.5 to 5 m). Data obtained from M.T.C. indicate this pit can produce G.B.C. A and H.L. 4 stone and may also be capable of producing other high-quality aggregate for asphalt paving mixes and structural concrete (Deike 1982).

The fifth area is a small ice-contact gravel deposit located in western Sullivan. The deposit contains pit 42 which has a face height of 10 feet (3 m) and contains 50 to 70 percent gravel. A sample taken from the pit contained 74 percent gravel, 24 percent sand, and 2 percent fines (Figure 3a).

The sixth area is a section of the Gibraltar Moraine which runs through southeastern Sullivan Township. The moraine contains licenced pits 9 and 10 which have face heights of 5 to 30 feet (1.5 to 9 m) with 10 to 75 percent gravel, as well as abandoned pits 57 to 60, 67, 68, 73 and 74. The abandoned pits contain 5 to 25 percent gravel and have face heights of 3 to 30 feet (1 to 9 m). The moraine is characterized by great variability in terms of the quality of the material it contains. Data obtained from M.T.C. for various pits in the moraine indicate that most tested pits can produce G.B.C. A, 16 mm Crushed Type B and in some cases H.L. 4 and 8 stone. Selection is often required to meet product specifications.

Three small gravel eskers and a gravel ice-contact-delta located in southwestern Sullivan Township are the final deposits to be discussed at the secondary level of significance. Pit 70, developed in an esker, contains 30 to 50 percent gravel and has a face height of 15 to 30 feet (5 to 9 m). The deposit contains approximately 10 percent oversize. The esker immediately to the east is expected to be similar in character. The esker to the north contains licenced pit 8 which has 10- to 20-foot (3 to 6 m) faces and contains 30 to 50 percent gravel. There are occasional layers of silt in the pit face. Pit 63 in the ice-contact-delta contains 40 to 50 percent gravel and has face heights of 20 to 25 feet (6 to 8 m). The deposit contains up to 10 percent oversize and some cemented material. Further testing is required in all four of these deposits to establish their quality.

BEDROCK GEOLOGY

Two bedrock units of Silurian age occur in Sullivan Township. The older Guelph Formation underlies most of the township. The Guelph Formation is a tan to brown, even-textured, fine- to medium- crystalline dolostone which appears vuggy and porous in reefal complexes (Liberty 1966). The formation has a high chemical purity and is a valuable raw material for numerous metallurgical products. It is quarried for the manufacture of dolomitic lime near Guelph and Hamilton. In the area of Sullivan Township, the formation is very pure, generally possessing less than 1 percent impurities (B.H. Feenstra, Mineral Resources Geologist, Ontario Ministry of Natural Resources, London, personal communication, 1982). At the turn of the century, rock from the formation was used in many localities in Grey County for the manufacture of lime for local use. Where outcrops of the formation were not available, boulders of the Guelph Formation contained in surficial materials were also used for this purpose (B.H. Feenstra, personal communication, 1982).

The Guelph Formation contains thick- to thin-bedded, reefal and inter-reefal dolomitic strata. The evenly bedded inter-reefal strata are better suited for use as aggregate than the steeply dipping, coarser grained, softer, more porous, and very fossiliferous reefal beds (B.H. Feenstra, personal communication, 1982). The geological processes which form natural gravel can cause the weaker parts of the Guelph Formation to be reduced to fine aggregate, while allowing the strong durable parts of the formation to remain intact in the gravel fraction. Natural gravel which has been derived from the Guelph Formation can, therefore, be suitable for use as load-bearing aggregate if it has undergone sufficient abrasion. This natural selection cannot be economically duplicated when the Guelph Formation itself is crushed for use as aggregate. The crushed stone consequently contains inherent weaknesses which make it unsuitable for use as load-bearing aggregate.

The karstified condition of the Guelph Formation and a generally high water table are additional constraints on the use of the formation for the production of construction aggregate (B.H. Feenstra, personal communication, 1982). For these reasons, no bedrock resources have been selected in Sullivan Township. Although the Guelph Formation is a possible source of raw material in various metallurgical processes, a lack of immediate local markets limits its use at the present time (B.H. Feenstra, personal communication, 1982).

The Salina Formation underlies a very small area in the southwest corner of the township. The formation is predominantly thin-bedded, soft, green and red shale with anhydrite, mineral molds, and thin bituminous partings. It also contains buff, fine-crystalline dolostone and some greenish and bluish grey shale (Liberty 1966). The soft shales and evaporite deposits of the Salina Formation have poor resistance to erosion and abrasion. The formation is not suitable for use as load-bearing aggregate.

The drift thickness is variable in Sullivan, ranging from areas of less than 3 feet (1 m) to greater than 172 feet (52 m). As Map 3 illustrates, a relatively

large portion of the township is overlain by either less than 50 feet (15 m) or less than 25 feet (8 m) of drift. These conditions occur predominantly in the northern half of the township, although scattered areas occur to the south and along the eastern border. Outcrops of the Guelph Formation are found in two locations in the township. Numerous outcrops occur in the Chatsworth area and north and northwest of Desboro.

SUMMARY

The sand and gravel resources of Sullivan Township were deposited during the Great Ice Age. Three areas of outwash sand and gravel deposits have been selected for possible resource protection at the primary level. These resource areas contain aggregate suitable for use as road-building and construction products. In addition, several ice-contact deposits have been selected at the secondary level. These deposits are also important parts of the total aggregate supply.

Most of the township is underlain by bedrock of the Guelph Formation. A small portion of the southwest corner of the township is underlain by the Salina Formation. The Guelph and Salina Formations are unacceptable for use as construction aggregate. Although some areas are overlain with less than 50 feet (15 m) of drift, no areas were selected for resource protection.

Enquiries regarding the Aggregate Resources Inventory of Sullivan Township should be directed to the Ontario Ministry of Natural Resources either at the Owen Sound District Office, 611-9th Avenue East, Owen Sound, Ontario, N4K 3E4 (Tel. (519) 376-3860) or at the Southwestern Region Geological Office, 458 Central Avenue, London, Ontario, N6B 2E5 (Tel. (519) 433-8431).

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, SULLIVAN TOWNSHIP.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
1	G-E	85 (34)	5 (4)
	G-IC-LD	64 (26)	4 (4)
	G-IC-E	56 (23)	3 (3)
	G-K	21 (8)	1 (1)
	S-IC	680 (275)	34 (31)
	S-IC-LD	10 (4)	1 (1)
	S-OW	16 (6)	<1 (<1)
2	G-E	103 (42)	4 (4)
	G-IC	690 (280)	23 (21)
	G-IC-LD	345 (140)	15 (14)
	G-K	87 (35)	3 (3)
	G-OW	2440 (990)	90 (82)
	S-AL	140 (57)	4 (4)
	S-E	210 (85)	8 (7)
	S-IC	4900 (1980)	178 (162)
	S-IC-E	16 (6)	<1 (<1)
	S-IC-LD	20 (8)	1 (1)
	S-OW	930 (375)	34 (31)
3	G-IC	88 (36)	2 (2)
	G-K	20 (8)	<1 (<1)
	G-OW	72 (29)	1 (1)
	S-AL	200 (81)	4 (4)
	S-E	285 (115)	6 (5)
	S-IC	660 (265)	13 (12)
	S-K	305 (123)	9 (8)
	S-OW	2410 (980)	48 (44)
4	S-IC	760 (310)	8 (7)
	S-K	12 (5)	<1 (<1)
		15,600 (6300)	500 (455)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 2. SAND AND GRAVEL PITS, SULLIVAN TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
LICENCED PITS							
1	M04-116	A. Kuhl	1&2	7	28.0 (11.3)	15-18 (5-6)	30-50
2	M04-136	N. Gilchrist	Pt.1	7	99.0 (40.1)	15-20 (5-6)	10-70
3	M04-137	H. Feenstra	Pt.2	3	60.1 (24.3)	25-35 (8-11)	20-50
4	M04-140	E.C. King Contracting	3	3	14.3 (5.8)	25-30 (8-9)	30-60
5	-	Harold Sutherland Const. Ltd.	Pt.2	2	4.8 (1.9)	30-35 (9-11)	50-60
6	C21-071	W. Lembke	Pt.15	12	12.4 (5.0)	5-10 (1.5-3)	10-30
7	M04-148	Township of Sullivan	Pt.16	5	99.8 (40.4)	5-20 (1.5-6)	20-60
8	-	W. Schwartz	27	11	25.0 (10.1)	10-20 (3-6)	30-50
9	M04-070	H. Davey	25	2	147.7 (59.8)	15 (5)	10-65
10	M04-025	H. Davey	Pt.24	1W &2	99.2 (40.1) 590.3 (238.9)	5-30 (1.5-9)	10-75
UNLICENCED PITS*							
11	-	Unknown	2	12		5-7 (1.5-2)	20-40 (partially overgrown)
12	-	Unknown	3	12		5-7 (1.5-2)	- (overgrown)
13	-	Unknown	4	12		10-15 (3-5)	- (overgrown)
14	-	Unknown	5	13		5-7 (1.5-2)	5-10 (partially
15	-	Unknown	7	13		7-18 (2-6)	10-20
16	C12-029	Unknown	6	12		7-25 (2-8)	5-20
17	-	Unknown	6	9		15- 18 (5-6)	10-40 (partially overgrown)
18	-	Unknown	7	9		15-25 (5-8)	30-40
19	-	Unknown	7	3		30-40 (9-12)	45-70 (partially overgrown)
20	-	Unknown	C	3		3-5 (1- 1.5)	- (overgrown)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables

*Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 2. SAND AND GRAVEL PITS, SULLIVAN TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
21	-	Unknown	D	3		10-12 (3-4)	40-60 (partially sloughed)
22	-	Unknown	10	2		15 (5)	35-50 (partially overgrown)
23	-	Unknown	5	1W		8-10 (2-3)	5-10 (partially overgrown)
24	M04-023	Farrow Bros.	6	1W		5-20 (1.5-6)	- (overgrown)
25	-	Unknown	A	2		5-7 (1.5-2)	- (partially overgrown)
26	M04-078	McNabb	B	2		10-12 (3-4)	30-65 (partially overgrown)
27	-	Unknown	C	2		5-10 (1.5-3)	35-50
28	-	Unknown	D	2		5-15 (1.5-5)	40-50 (partially overgrown)
29	-	Unknown	10	12		7-10	-
30	-	Unknown	10	12		7-12 (2-4)	- (overgrown)
31	-	Unknown	12	12		10-12 (3-4)	10-25 (partially overgrown)
32	-	Unknown	12	12		15 (5)	- (partially overgrown)
33	-	Unknown	10	9		5-10 (1.5-3)	30-35 (partially overgrown)
34	-	Unknown	11	4		10-12 (3-4)	30-45
35	-	Unknown	13	4		5-6 (1.5-2)	- (partially overgrown)
36	M04-081	S. Fay	14	4		5-15 (1.5-5)	20-50 (partially overgrown)
37	-	Unknown	K	2		5 (1.5)	5
38	M04-11	Dixon	10	1W		10-12 (3-4)	10-60
39	-	Ministry of Natural Resources	14	2		5-10 (1.5-3)	5-10 (partially rehabilitated
40	-	Ministry of Natural Resources	14	1W		5-10 (1.5-3)	5-10 (partially overgrown)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 2. SAND AND GRAVEL PITS, SULLIVAN TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
41	M04-022	Specht	11	1W		7-15 (2-5)	40-70 (partially overgrown)
42	-	Unknown	17	12		10 (3)	50-70
43	-	Unknown	17	9		5-10 (1.5-3)	- (partially overgrown)
44	-	W. Albright	16	8		5 (1.5)	40-60 (partially rehabili- tated
45	-	Unknown	18	5		5-10 (1.5-3)	5-10 (partially overgrown)
46	-	Golem	21	13		3-6 (1-2)	10-15 (partially overgrown)
47	-	Unknown	20	4		10-12 (3-4)	50-65 (partially overgrown)
48	-	Unknown	20	4		5- 8 (1.5-2)	30-55 (partially overgrown)
49	-	Unknown	21	4		5-8 (1.5-2)	30-40 (partially overgrown)
50	-	Unknown	21	4		5- 8 (1.5-2)	30-40 (partially overgrown)
51	-	Unknown	21	4		5-8 (1.5-2)	30-40 (partially overgrown)
52	-	Unknown	22	4		3- 4 (1-1.2)	30-45 (partially overgrown)
53	-	Unknown	22	4		15 (5)	50-60 (partially overgrown)
54	-	Unknown	22	4		10-12 (3-4)	50-70
55	-	Unknown	21	4		12 (4)	25-35 (partially overgrown)
56	-	Unknown	20	4		15 (5)	25-40 (partially overgrown)
57	-	Unknown	22	3		9 (3)	- (overgrown)
58	-	Unknown	22	1W		3 (1)	- (overgrown)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 2. SAND AND GRAVEL PITS, SULLIVAN TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
59	M04-038	Davidson	21	1W		10-30 (3-9)	25 (partially overgrown)
60	M04-037	Newman	22	1W		15 (5)	- (overgrown)
61	-	Unknown	25	11		10-15 (3-5)	- (partially overgrown)
62	-	Unknown	24	8		5 (1.5)	40 (partially overgrown)
63	-	Unknown	24	8		20-25 (6-8)	40-50 (partially overgrown)
64	-	Unknown	24	7		3-4 (1-1.2)	- (partially overgrown)
65	-	Unknown	24	7		10-15 (3-5)	20-25 (partially overgrown)
66	-	Unknown	24	6		25-35 (8- 11)	- (overgrown)
67	-	Unknown	24	4		6-12 (2-4)	- (partially overgrown)
68	-	Unknown	23	1W		5-15 (1.5-5)	5-20 (partially overgrown)
69	-	Unknown	30	12		10-15 (3-5)	- (overgrown)
70	-	Unknown	30	12		15-30 (5-9)	30-50 (partially overgrown)
71	-	Unknown	28	11		5-10 (1.5-3)	10-20
72	-	Unknown	28	10		10-15 (3-5)	10-25
73	-	Unknown	26	6		3-5 (1-1.5)	5-10
74	M04-069	Soyka	26	1W		10 (3)	10- 20 (overgrown)
75	M04-049	McCraken	29	1W		10 (3)	80 (overgrown)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, SULLIVAN TOWNSHIP.

1 Deposit No.	2 Unlicenced Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
1a	1750 (710)	440 (178)	20 (8)	1290 (520)	15 (5)	48 (44)
1b	85 (34)	10 (4)	0 (0)	75 (30)	15 (5)	3 (3)
1c	145 (59)	70 (28)	10 (4)	65 (26)	12 (4)	2 (2)
1d	210 (85)	45 (18)	5 (2)	160 (65)	15 (5)	6 (5)
	2190 (890)	560 (227)	35 (14)	1590 (640)		59 (54)
2a	840 (340)	100 (40)	10 (4)	730 (295)	15 (5)	27 (24)
2b	80 (32)	40 (16)	0 (0)	40 (16)	10 (3)	1 (1)
	920 (370)	140 (57)	10 (4)	770 (310)		28 (25)
3	210 (85)	40 (16)	10 (4)	160 (65)	15 (5)	6 (5)
	3300 (1340)	740 (300)	55 (22)	2500 (1010)		93 (84)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCES, SULLIVAN TOWNSHIP

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
25-50 (8-15)	Salina Formation	60 (18)	50 (20)	10 (9)
0-3 (0-1)	Guelph Formation	60 (18)	1120 (455)	240 (218)
3-25 (1-8)	Guelph Formation	60 (18)	9700 (3950)	2100 (1900)
25-50 (8- 15)	Guelph Formation	60 (18)	20,100 (8100)	4350 (3950)
			31,000 (12 500)	6700 (6100)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 5. QUARRIES, SULLIVAN TOWNSHIP.

1 NO.	2 MTC NO.	3 OWNER/ OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)

-NONE-

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, SULLIVAN TOWNSHIP.

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)

-NONE-

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 7. SUMMARY OF TEST HOLE DATA, SULLIVAN TOWNSHIP.

-NONE-

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 8. DESCRIBED SECTIONS, SULLIVAN TOWNSHIP.

Described Section Number: SU-DS-1
Location: Conc. 2, Lot 7
Elevation: 950 feet (290 m) above sea level (a.s.l.)

Depth feet (metres)	Description
0-4.0 (0-1.2)	stratified ice-contact gravelly sand (28% gravel, 68.5% sand, 3.5% fines)

Described Section Number: SU-DS-2
Location: Conc. 5, Lot 16
Elevation: 1050 feet (320 m) a.s.l.

Depth feet (metres)	Description
0-7.0 (0-2.1)	ice-contact sand and gravel (39% gravel, 59.5% sand, 1.5% fines)

Described Section Number: SU-DS-3
Location: Conc. 2, Lot 28
Elevation: 1150 feet (350 m) a.s.l.

Depth feet (metres)	Description
0-3.5 (0-1.1)	pebbly and cobbly, silty fine to coarse sand (33% gravel, 62% sand, 5% fines)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

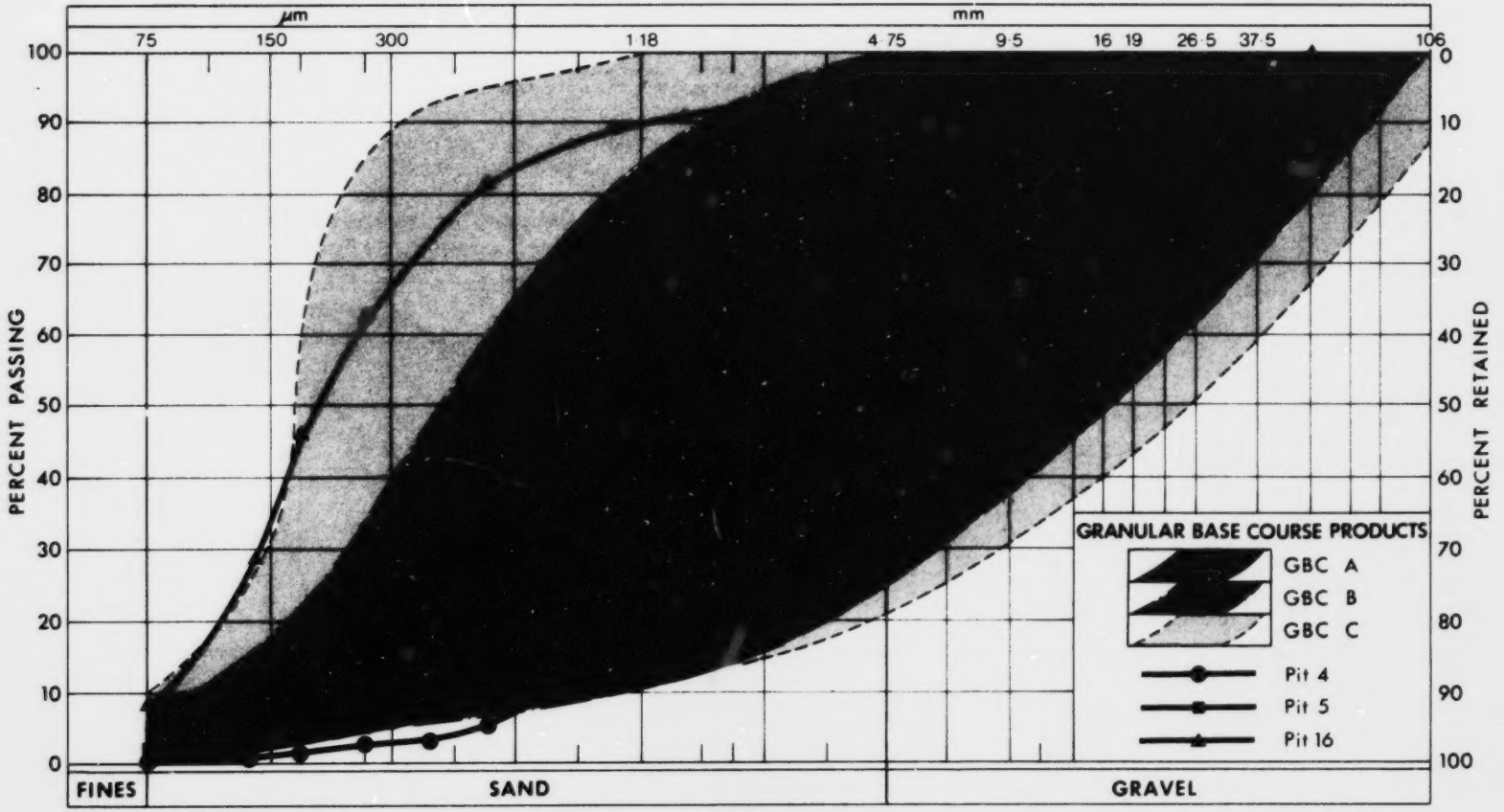


FIGURE 2a: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

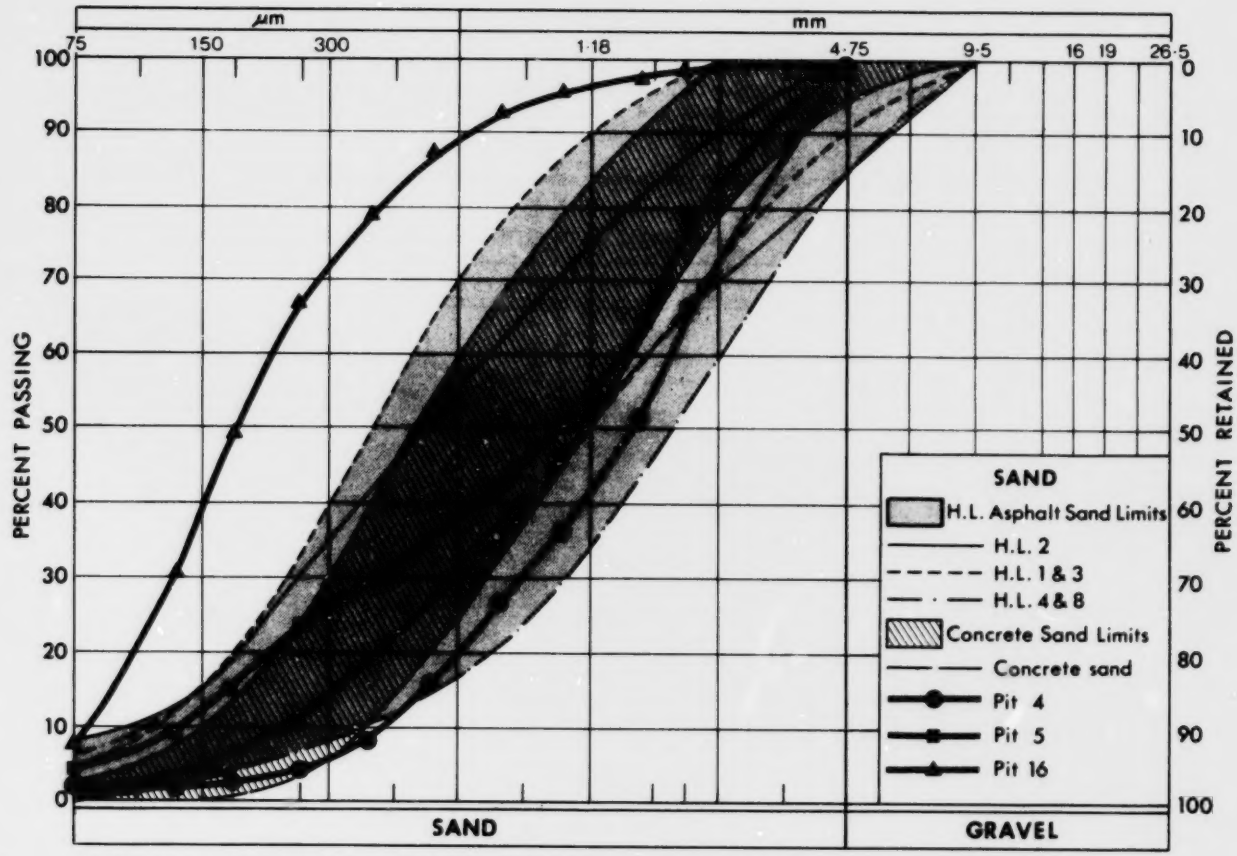


FIGURE 2b: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

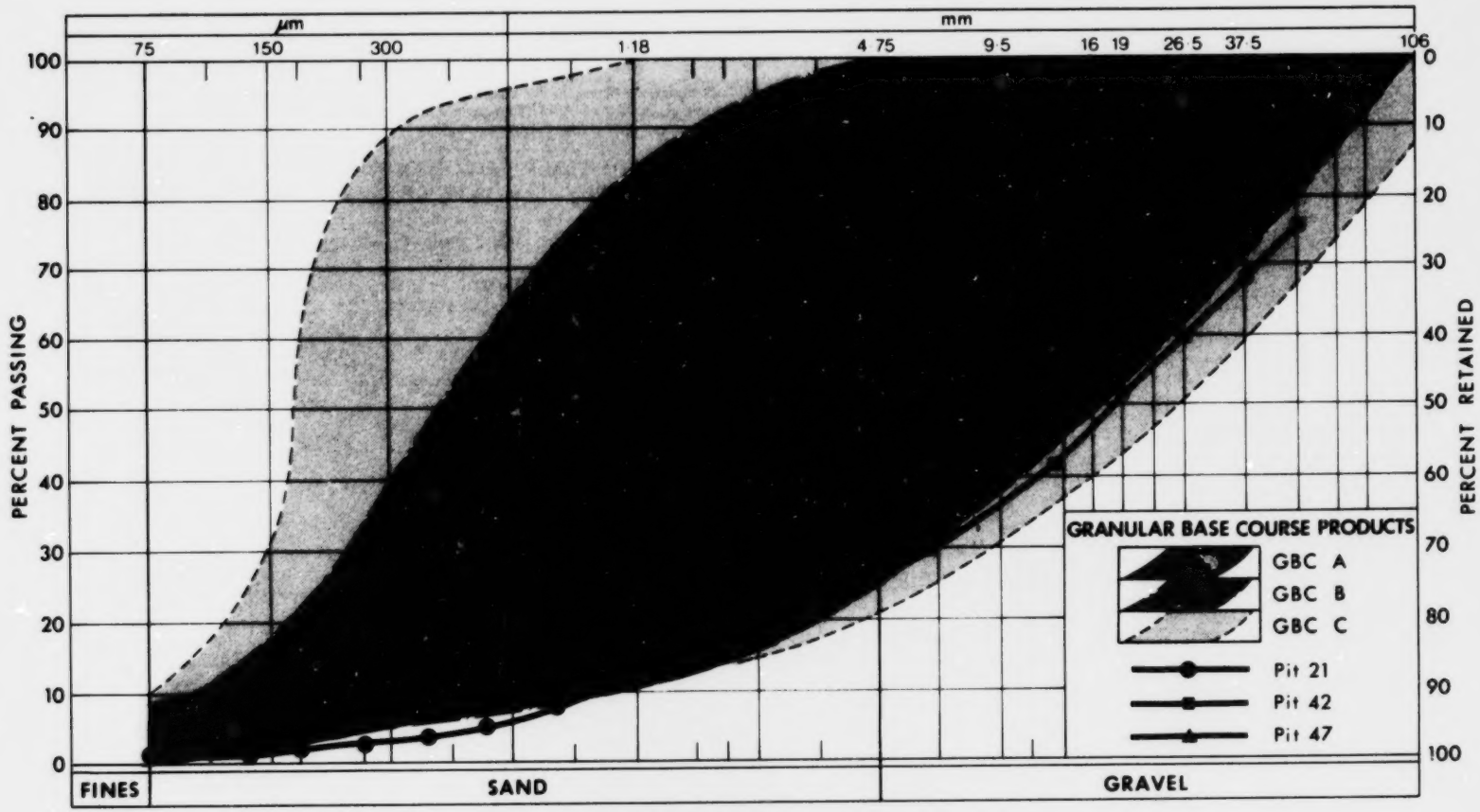


FIGURE 3a: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

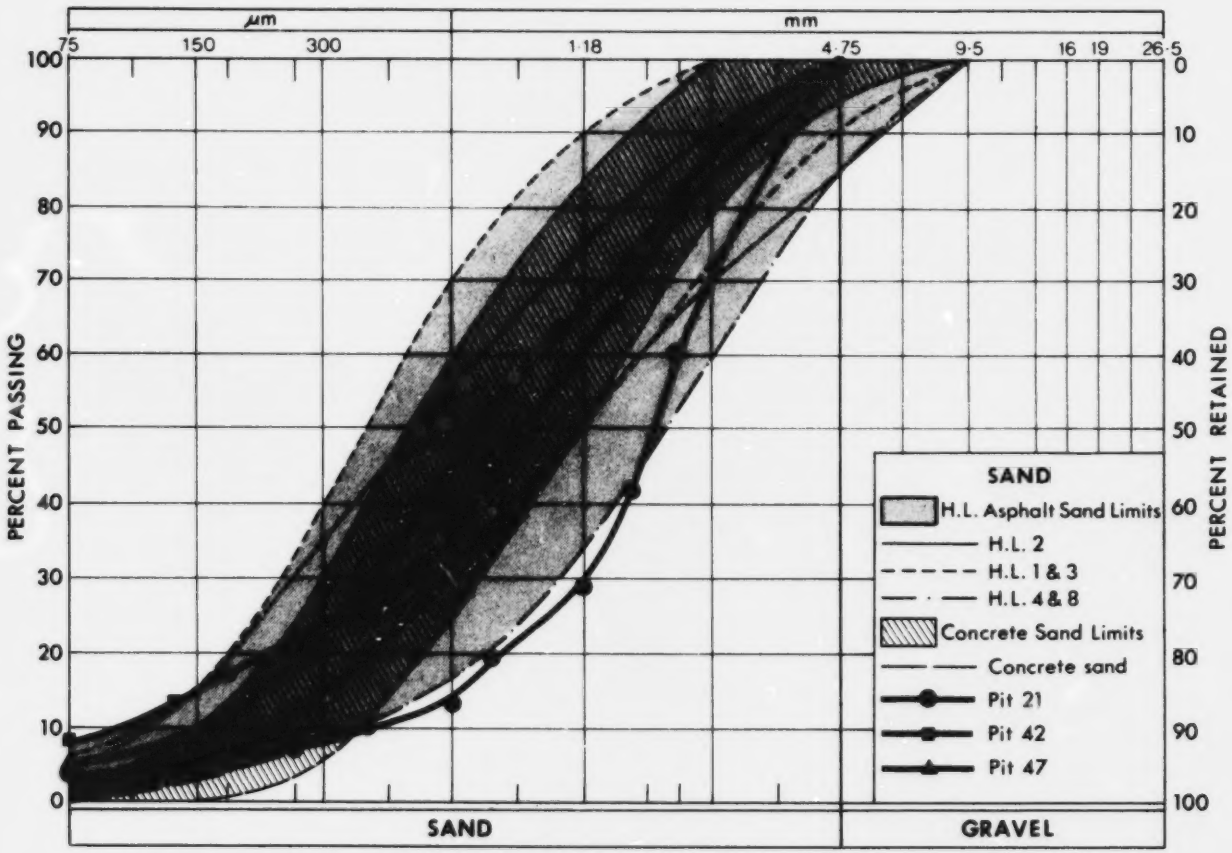


FIGURE 3b: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

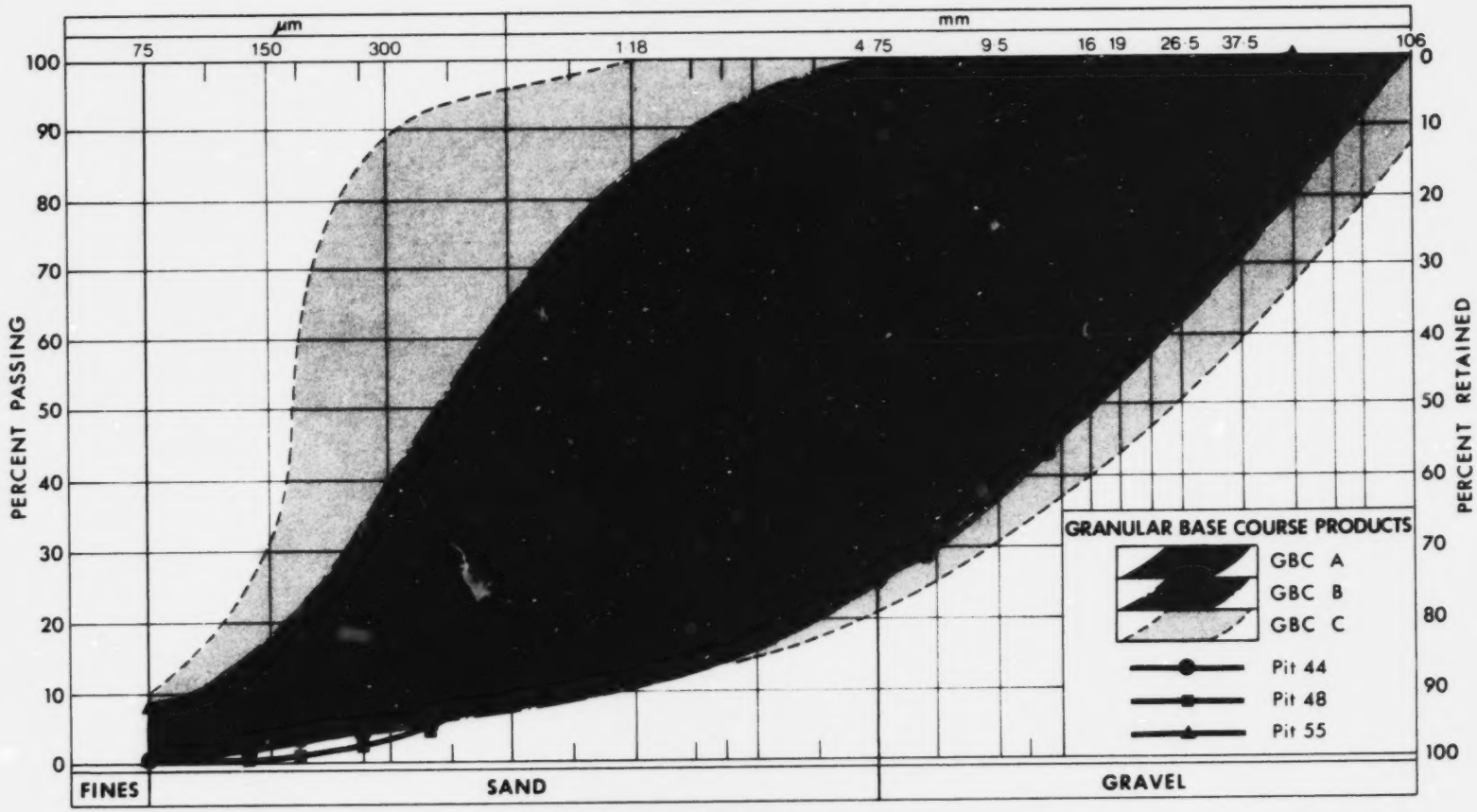


FIGURE 4a: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

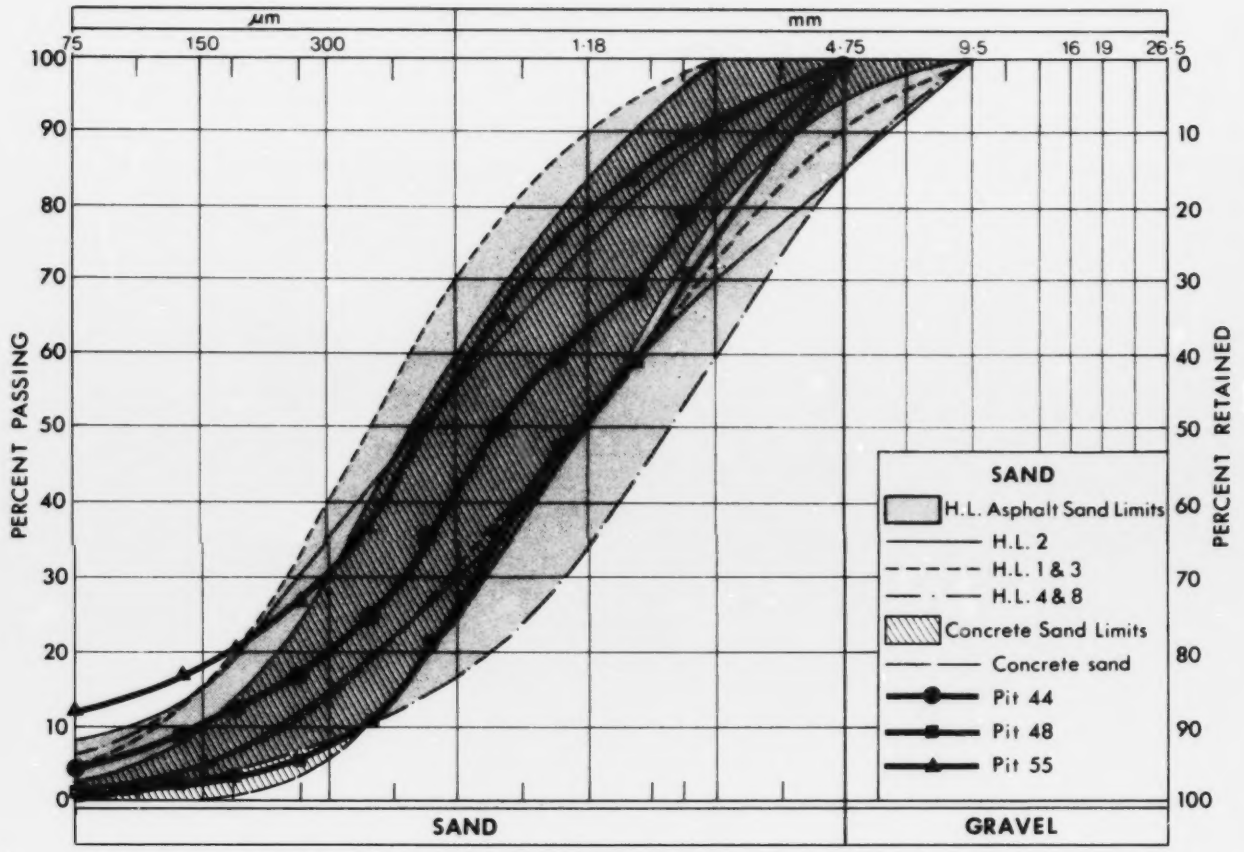


FIGURE 4b: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

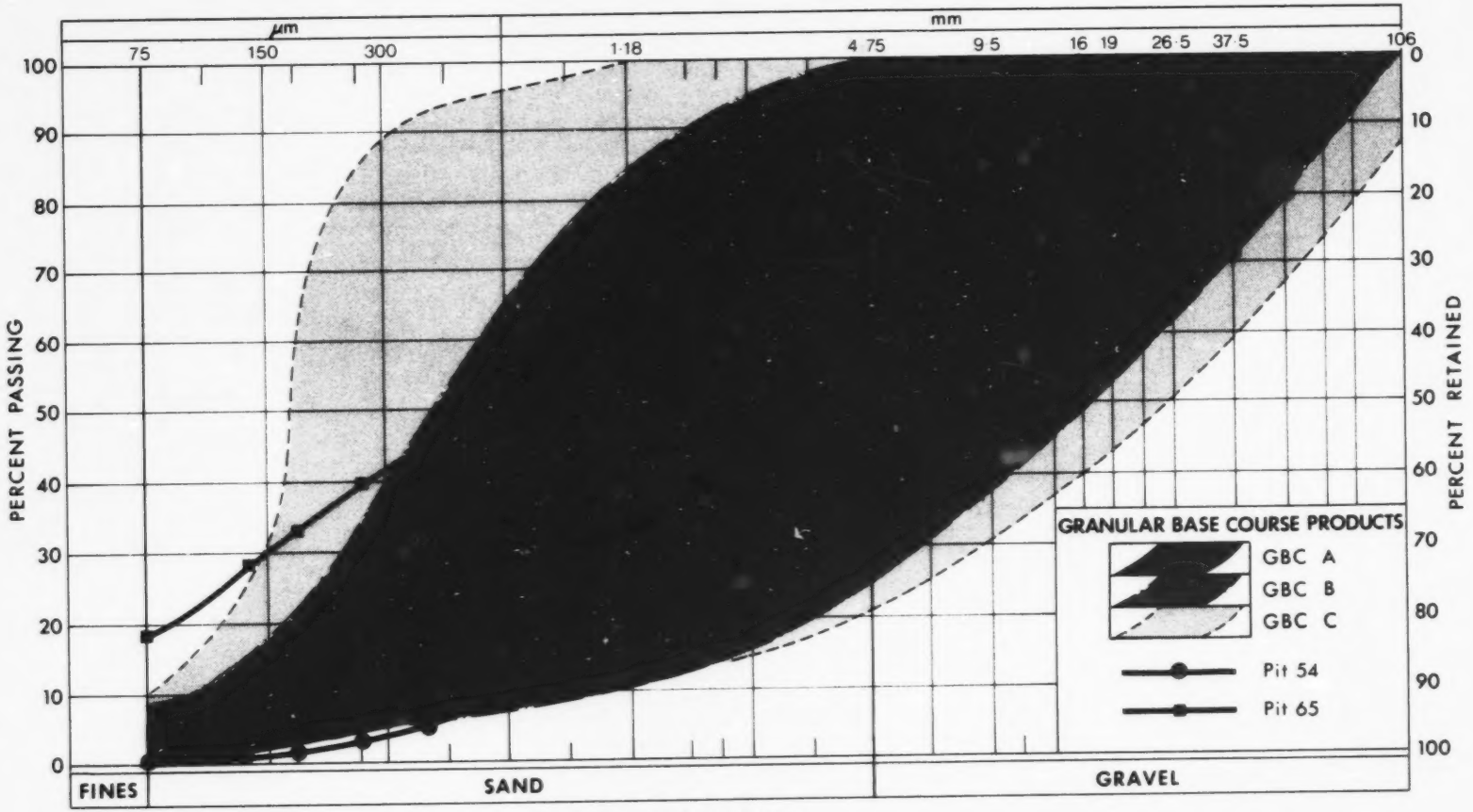


FIGURE 5a: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

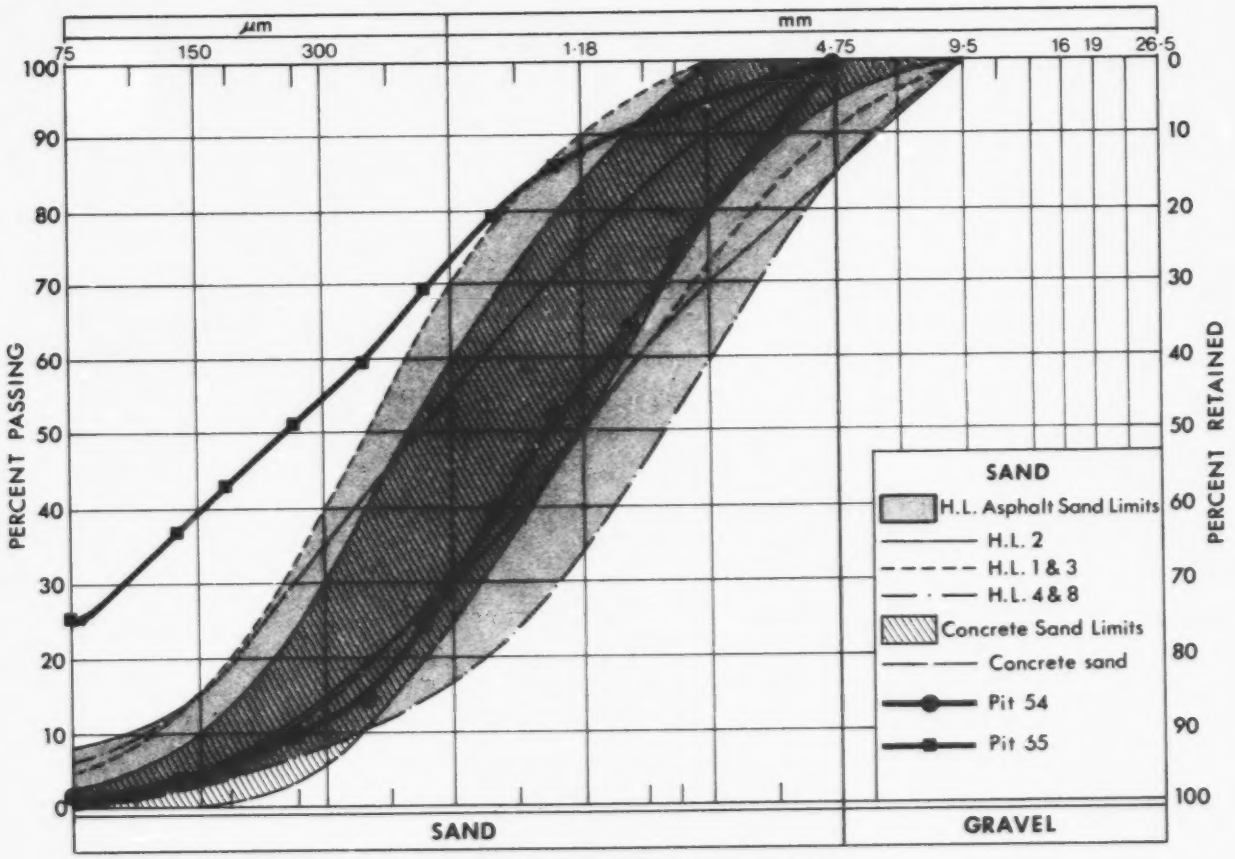


FIGURE 5b: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

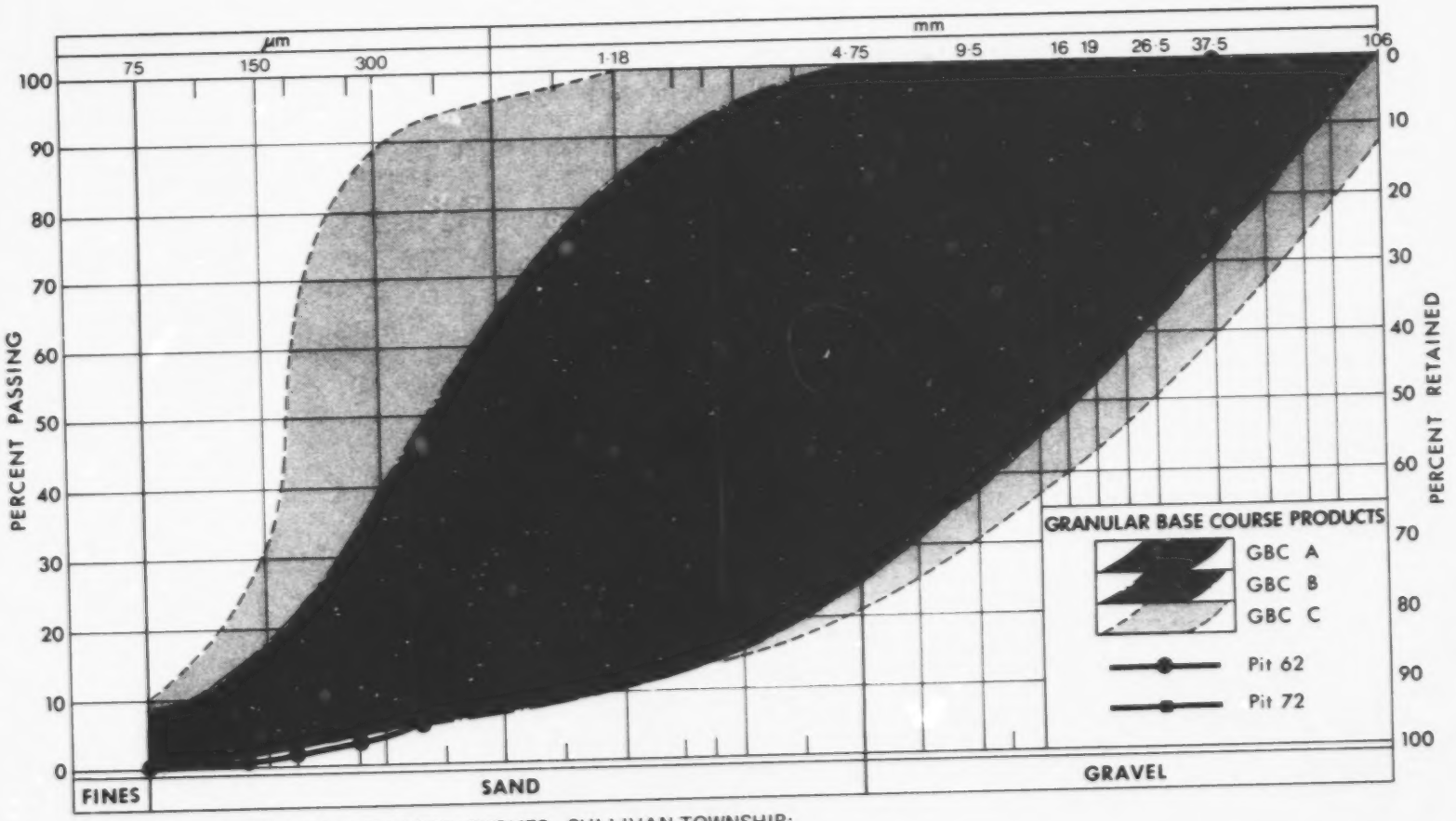


FIGURE 6a: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

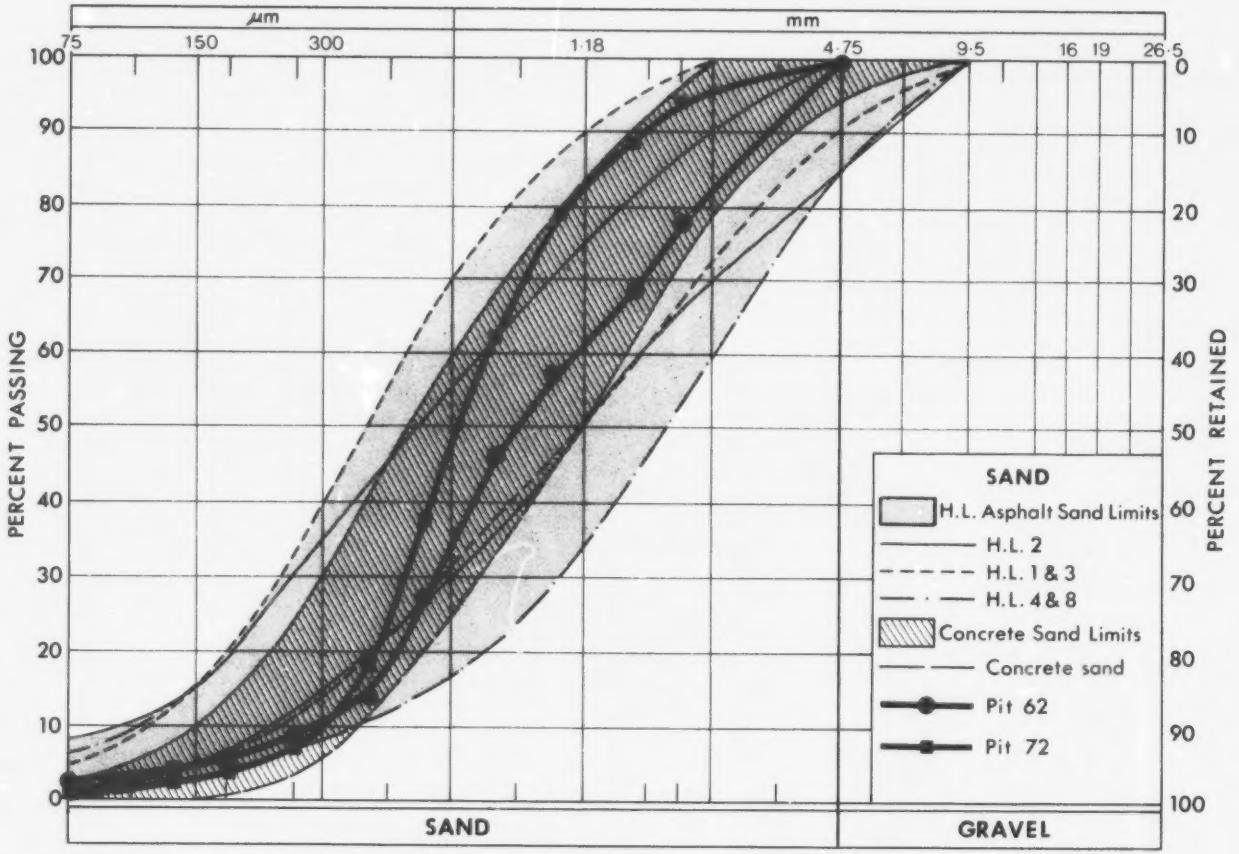


FIGURE 6b: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

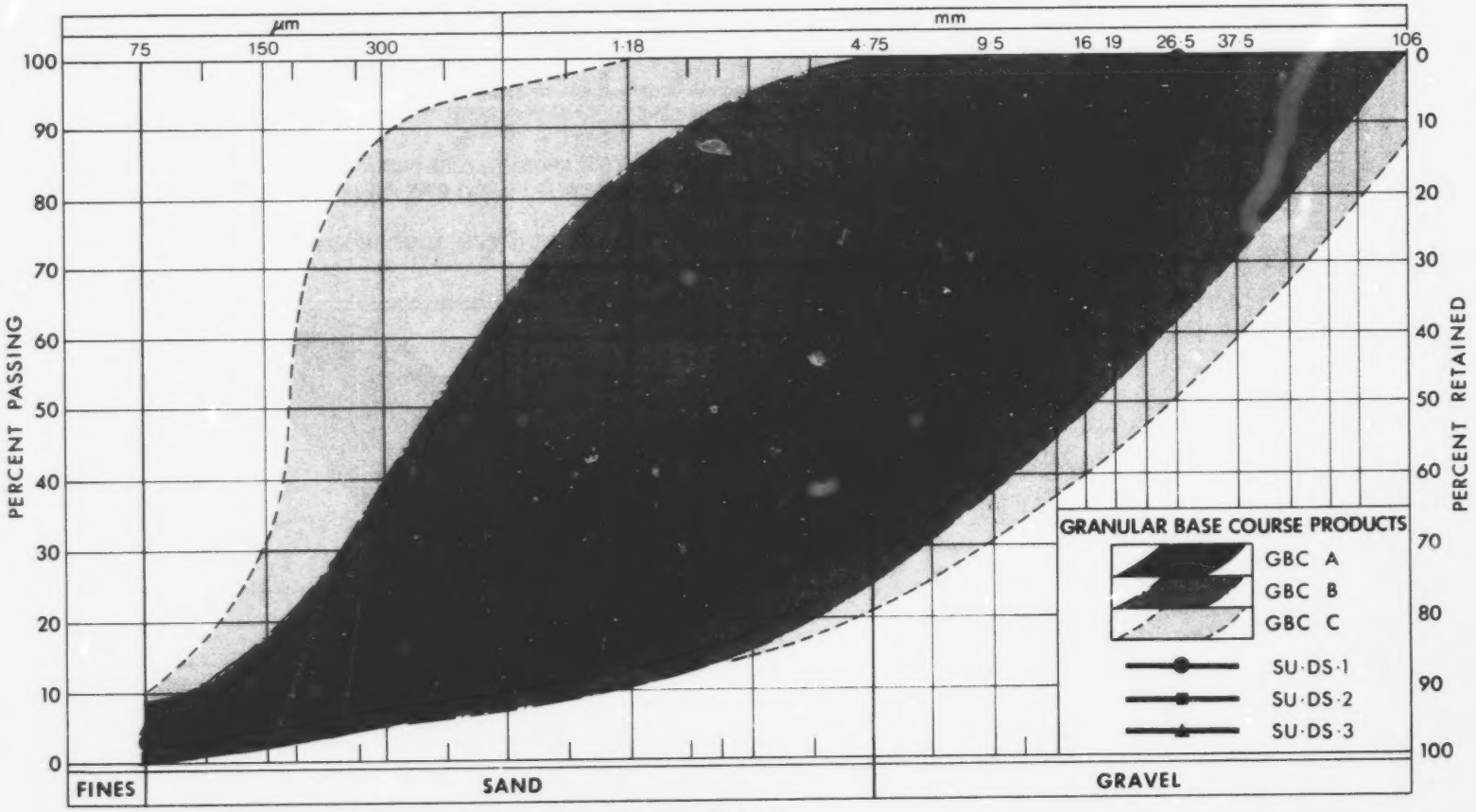


FIGURE 7a: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

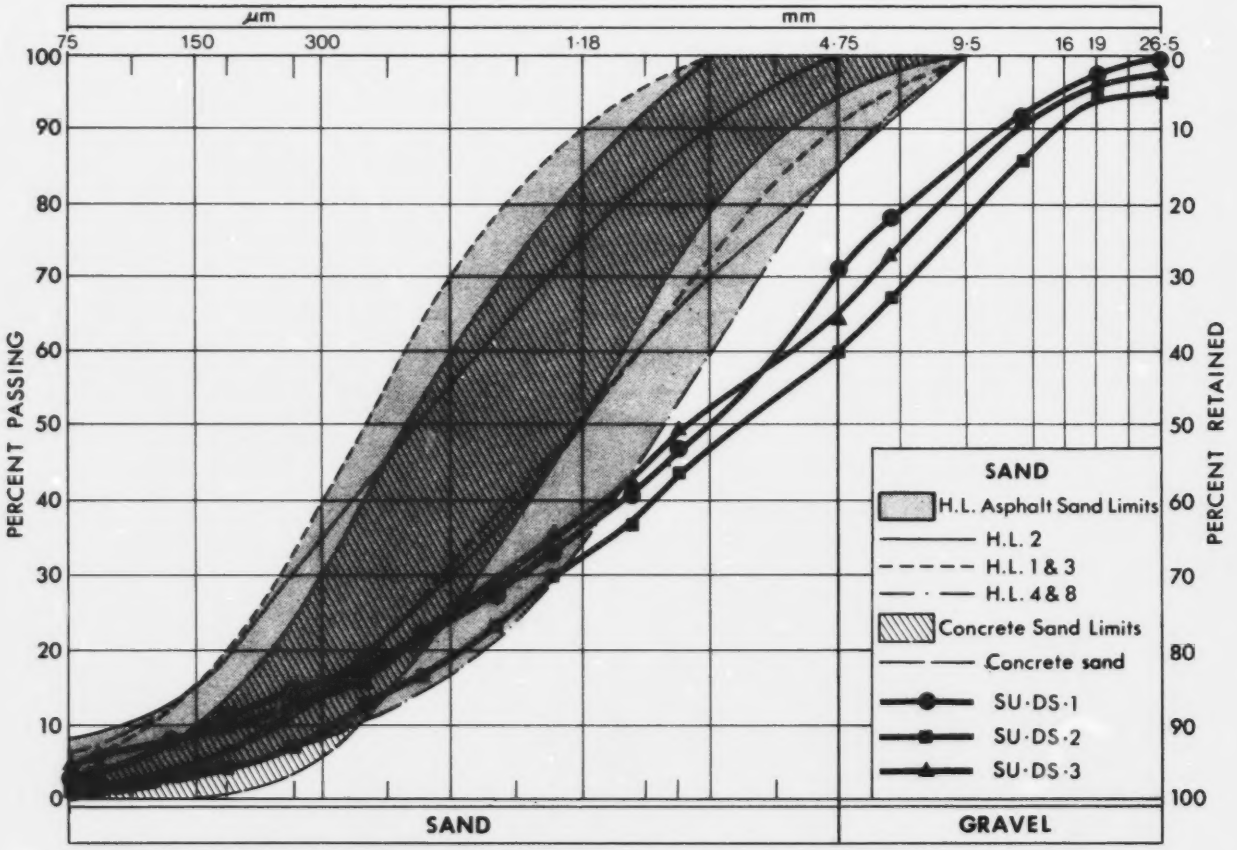


FIGURE 7b: AGGREGATE GRADING CURVES, SULLIVAN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

References

Association of Professional Engineers of Ontario
1976: Performance Standards for Professional Engineers Advising on and Reporting on Oil, Gas and Mineral Properties; Association of Professional Engineers of Ontario, 11 p.

Chapman, L.J. and Putnam, D.F.
1966: The Physiography of Southern Ontario; Second Edition, Ontario Research Foundation, University of Toronto Press, Toronto, 386 p.

Deike, W.
1982: Aggregate Suitability Evaluation, Sullivan Township, Grey County; Aggregate Sources Research, 29 p., unpublished report.

Feenstra, B.H.
1975: Quaternary Geology of the Markdale Area (41 A/7), Grey County; pp. 116-118 in Summary of Field Work, 1975, by the Geological Branch, edited by V.G. Milne, D.F. Hewitt, K.D. Card and J.A. Robertson, Ontario Division of Mines, Miscellaneous Paper 63, 158 p.
in prep: Quaternary Geology of the Markdale Area, Southern Ontario; Ontario Geological Survey, report in preparation.

Leyland, W.J.
1979: An Investigation of Two Eskers in the Chatsworth, Ontario Area; University of Western Ontario, Department of Geology, unpublished B.Sc. Thesis, 118 p.

Liberty, B.A.
1966: Geology of the Bruce Peninsula, Ontario; Geological Survey of Canada, Paper 65-41, 8 p., 13 maps, scale 1:63 360.

Liberty, B.A. and Bolton, T.E.
1971: Paleozoic Geology of the Bruce Peninsula Area, Ontario; Geological Survey of Canada, Memoir 360, 163 p., 1 chart, 1 map, scale 1:253 440.

Ontario
1983: Pits and Quarries Control Act; Revised Statutes of Ontario, 1980, Chapter 378, Queen's Printer for Ontario.

Ontario Interministerial Committee on National Standards and Specifications (Metric Committee)
1975: Metric Practice Guide; 67 p.

Ontario Ministry of Municipal Affairs and Housing
1983: Municipal Directory 1983; Queen's Printer for Ontario, 241 p.

Ontario Ministry of Natural Resources
1983: Statistics 1983; Ontario Ministry of Natural Resources, 123 p.

Ontario Ministry of Treasury, Economics and Intergovernmental Affairs
1974: 1974 Municipal Directory; Queen's Printer for Ontario; 128 p.

Owen Sound Planning Board
1976: Official Plan for the City of Owen Sound Planning Area; 33 p.

Robertson, J.A.
1975: Mineral Deposit Studies, Mineral Potential Evaluation, and Regional Planning in Ontario; Ontario Division of Mines, Miscellaneous Paper 61, 42 p.

Sharpe, D.R.
1975: Quaternary Geology of the Durham Area (41 A/2), Grey County; pp. 113-115 in Summary of Field Work, 1975, by the Geological Branch, edited by V.G. Milne, D.F. Hewitt, K.D. Card and J.A. Robertson, Ontario Division of Mines, Miscellaneous Paper 63, 158 p.

Sharpe, D.R. and Edwards, W.A.D.
1979: Quaternary Geology of the Chesley-Tiverton Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.2314, Geological Series, scale 1:50 000.

Sharpe, D.R., Hradsky, M. and Farrell, L.E.
1979: Drift Thickness of the Chesley-Tiverton Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.2316, Drift Thickness Series, scale 1:50 000.

Appendix A — Suggested Additional Reading

American Geological Institute
1972: Glossary of Geology; Washington, D.C., 858 p.

Bauer, A.M.
1970: A Guide to Site Development and Rehabilitation of Pits and Quarries; Ontario Department of Mines, Industrial Mineral Report 33, 62 p.

Cowan, W.R.
1977: Toward the Inventory of Ontario's Mineral Aggregates; Ontario Geological Survey, Miscellaneous Paper 73, 19 p.

Fairbridge, R.W. (ed.)
1968: The Encyclopedia of Geomorphology; Encyclopedia of Earth Sciences, Vol. III, Reinhold Book Corp., N.Y., 1295 p.

Flint, R.F.
1971: Glacial and Quaternary Geology; John Wiley and Sons Inc., 892 p.

Hewitt, D.F.
1960: The Limestone Industries of Ontario; Ontario Department of Mines, Industrial Mineral Circular 5, 177 p.
1964a: Building Stones of Ontario, Part I Introduction; Ontario Department of Mines, Industrial Mineral Report 14, 43 p.
1964b: Building Stones of Ontario, Part II Limestone; Ontario Department of Mines, Industrial Mineral Report 15, 43 p.
1964c: Building Stones of Ontario, Part III Marble; Ontario Department of Mines, Industrial Mineral Report 16, 89 p.
1964d: Building Stones of Ontario,. Part IV Sandstone; Ontario Department of Mines, Industrial Mineral Report 17, 57 p.
1972: Paleozoic Geology of Southern Ontario; Ontario Division of Mines, Geological Report 105, 18 p.

Hewitt, D.F. and Karrow, P.F.
1963: Sand and Gravel in Southern Ontario; Ontario Department of Mines, Industrial Mineral Report 11, 151 p.

Hewitt, D.F. and Vos, M.A.
1970: Urbanization and Rehabilitation of Pits and Quarries; Ontario Department of Mines, Industrial Mineral Report 34, 21 p.

Lowe, S.B.
1980: Trees and Shrubs for the Improvement and Rehabilitation of Pits and Quarries in Ontario; Ontario Ministry of Natural Resources, 71 p.

McLellan, A.G., Yundt, S.E. and Dorfman, M.L.
1979: Abandoned Pits and Quarries in Ontario; Ontario Geological Survey, Miscellaneous Paper 79, 36 p.

Ontario Mineral Aggregate Working Party
1977: A Policy for Mineral Aggregate Resource Management in Ontario; Ontario Ministry of Natural Resources, 232 p.

Ontario Ministry of Natural Resources
1975: Vegetation for the Rehabilitaion of Pits and Quarries; Forest Management Branch, Division of Forests, 38 p.

Peat, Marwick and Partners and M.M. Dillon Limited
1981: Mineral Aggregate Transportation Study; Industrial Mineral Background Paper 1, 133 p. Summary Report 26 p.

Proctor and Redfern Limited
1974: Mineral Aggregate Study, Central Ontario Planning Region; Prepared for the Ontario Ministry of Natural Resources, over 100 p.

Proctor and Redfern Limited and Gartner Lee Associates Limited
1975: Mineral Aggregate Study of Part of the Eastern Ontario Region; Prepared for the Ontario Ministry of Natural Resources, about 200 p.
1977: Mineral Aggregate Study and Geological Inventory, Southwestern Region of Ontario; Prepared for the Ontario Ministry of Natural Resources, about 200 p.

Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Alkali-aggregate reaction: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Cambrian: The first period of the Palezoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: an early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near- ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probabiltiy of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

Bass Islands Formation (Upper Silurian)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18 m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunnville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate because of high soundness losses.

Bobcaygeon Formation (Middle Ordovician)

Composition: Compact, homogeneous, medium- to thin-bedded, fine- grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

Bois Blanc Formation (Lower-Middle Devonian)

Composition: Brownish grey, medium-crystalline, medium- to thin- bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High cherty content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

Dundee Formation (Middle Devonian)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys as raw material for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

Gull River Formation (Middle Ordovician)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield and Unthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

Lockport and Amabel Formations (Middle Silurian)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive- bedded, fine-to medium-grained dolostone. Thickness: Amabel Formation: maximum observed

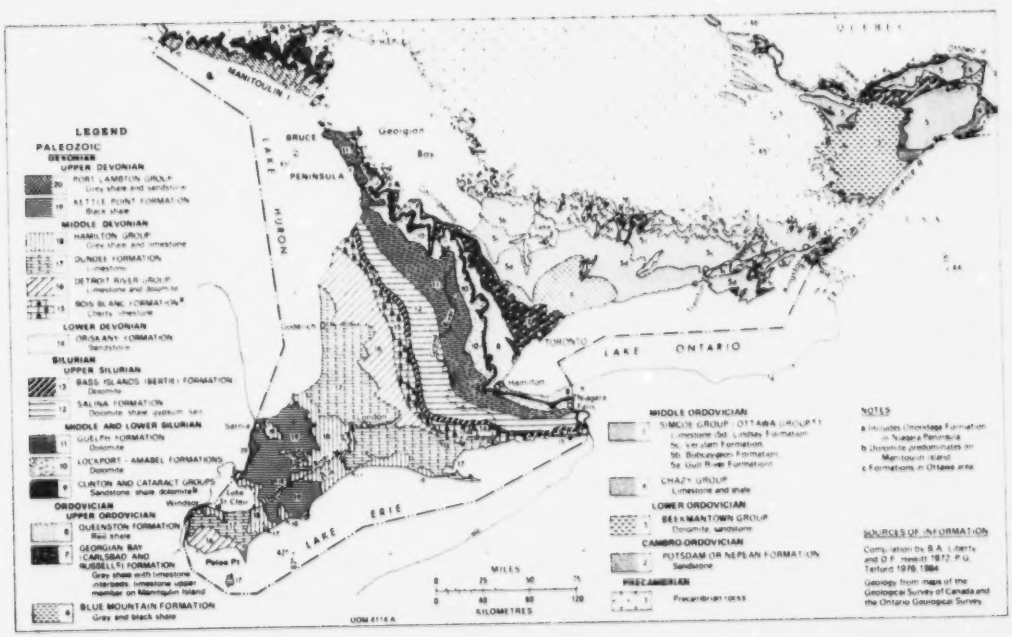


Figure 8. Bedrock Geology of Southern Ontario.

thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

Onondaga Formation (Middle Devonian)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium- grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey- brown, fine-grained, very cherty limestone having estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey-brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High cherty content makes much of the material unsuitable for concrete aggregate.

Ottawa Formation (Middle Ordovician)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of limestone for cement production and agricultural uses.

Oxford Formation (Lower Ordovician)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

Detroit River Group (Middle Devonian)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces much of Ontario's lime and cement. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

Grenville Marble (Precambrian)

Composition: Recrystallized fine- to coarse-grained white limestone and dolostone, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

Guelph Formation (Middle Silurian)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. Thickness: 100 to 170 feet (30 to 52 m). Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

Lindsay Formation (Upper Ordovician)

Composition: fine-crystalline, rubbly, nodular-weathering limestone. Collingwood Member: organic-rich interbedded calcareous shales and limestones. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

Verulam Formation (Middle Ordovician)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for use in cement manufacture. The formation is unsuitable for crushed stone because of clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

Georgian Bay Formation (Upper Ordovician) (Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue-grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in the vicinity of Metro Toronto produce brick and structural tile. Lightweight aggregate has been produced at Streetsville by heat expansion of the shale.

Hamilton Group (Middle Devonian)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona Formation is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). The Arkona Formation has a thickness of 14 to 121 feet (4 to 37 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile.

Queenston Formation (Upper Ordovician)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

Nepean (Potsdam) Formation (Cambro-Ordovician)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

Salina Formation (Upper Silurian)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

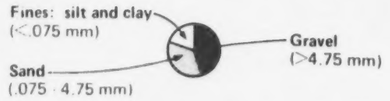
Blue Mountain Formation (Upper Ordovician)

(Formerly known as the Whitby Formation) Composition: Blue-grey, predominantly non-calcareous shale. Uses: Quarried at Bowmanville for use in cement production.

LEGEND

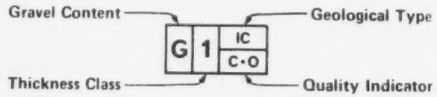
(continued from right margin)

TEXTURE SYMBOL



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

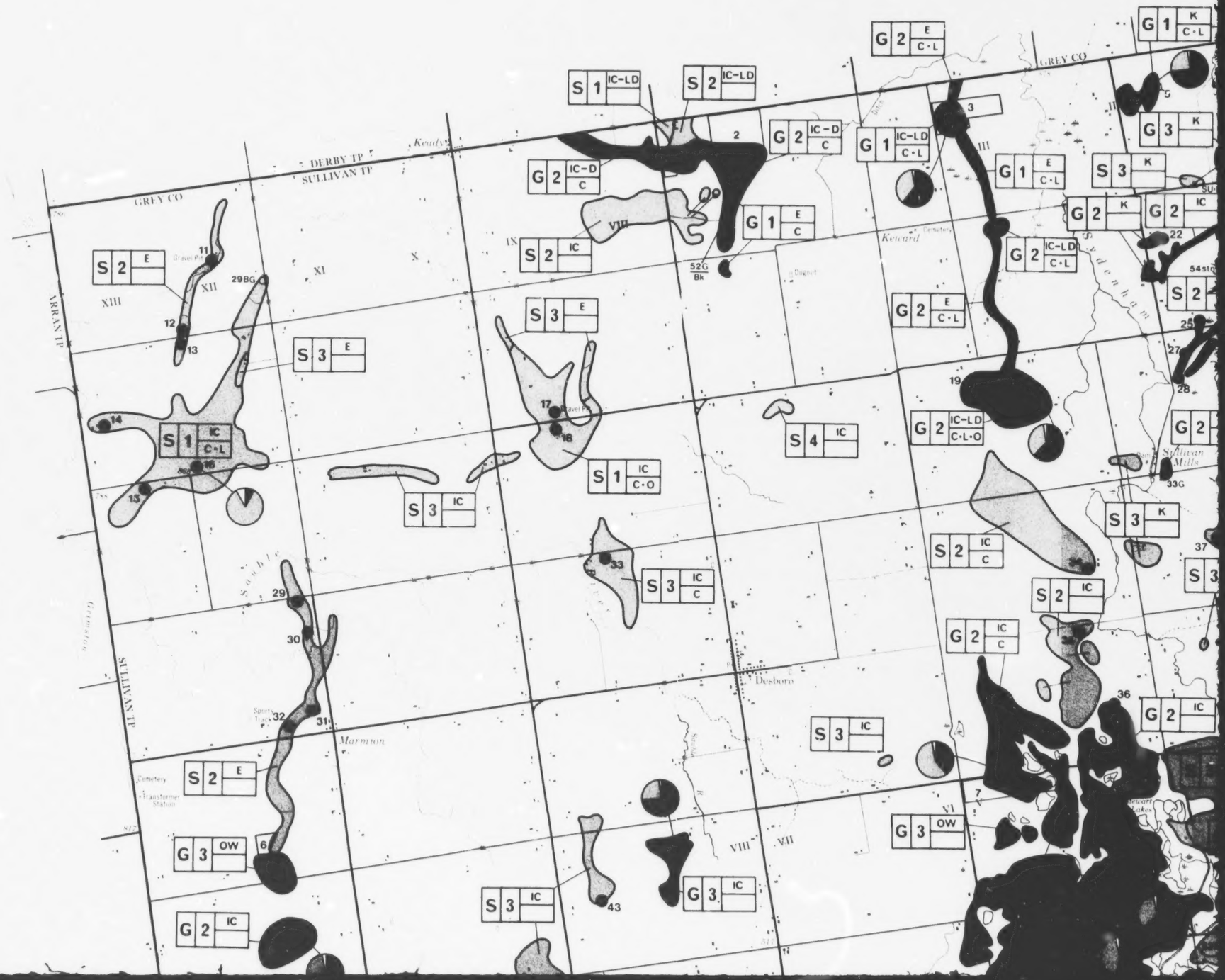
Geological Type

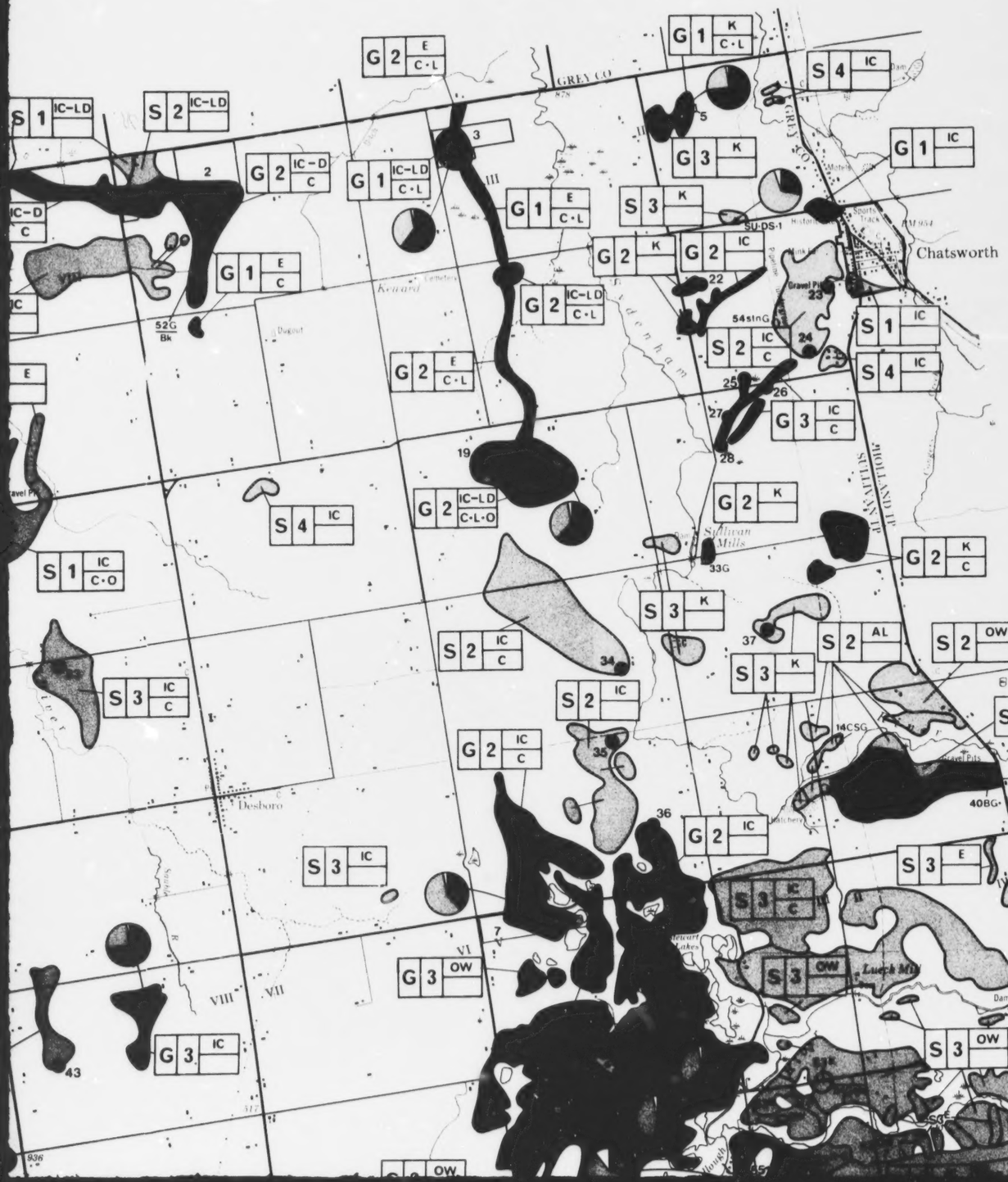
AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Organic particles or fragments present in objectionable





Ministry of Natural Resources

Ontario

Hon. Michael Harris
Minister

Mary Mogford
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

SULLIVAN TOWNSHIP

GREY COUNTY

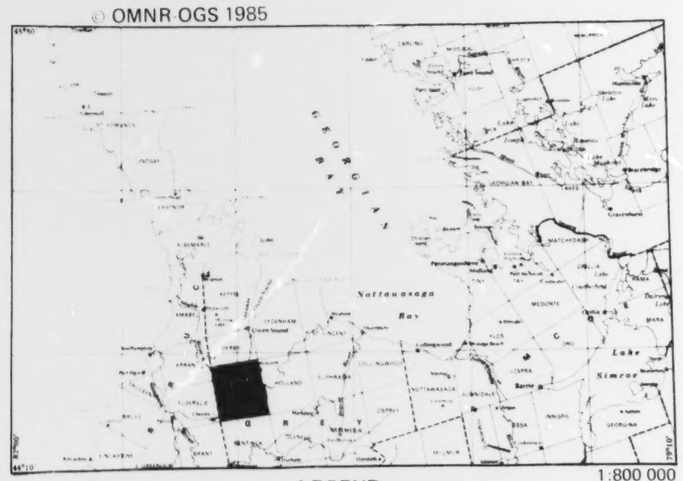
MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/6, 41 A/7



LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

- Gravel deposit.
- Sand deposit.
- Gravel overlain by other surficial material.
- Sand overlain by other surficial material.

G Greater than 35% gravel.
S Less than 35% gravel.

Thickness Class

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

If blank, no known limitations present.
C Clay and/or silt (fines) present in objectionable quantities.
L Deleterious lithologies present.
O Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.

Selected water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: B. H. Feenstra, in prep.
D. R. Sharpe and W. A. D. Edwards, 1979.

Additional Field Work by: Staff of the Aggregate Assessment Office.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 101.

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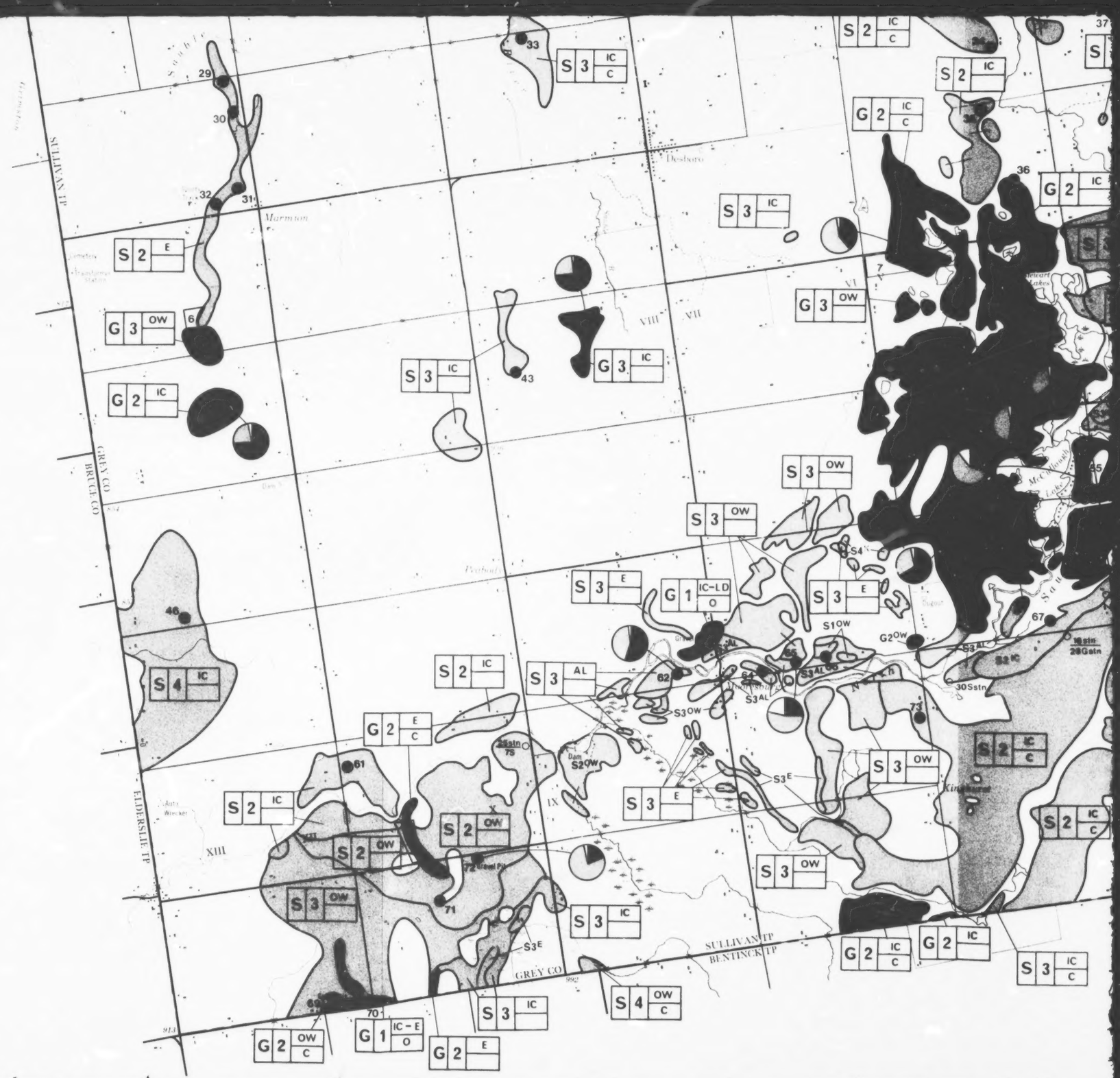
Issued 1985.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.


SULLIVAN TP
Marmora
Deseronto
GREY CO
BRUCE CO
ELDERSLIE TP
SULLIVAN TP
BENTINCK TP
Auto Wrecker
Gravel Pit
Dam
Kingsmere
McCormick Lakes
Belcourt Lakes
Deloro
Perfect
Sta 11
Sta 12
30Sstn
28Gstn
Mstn
Gstn
S3AL
S3OW
S3E
S1OW
G2OW
S2OW
S3AL OW
S3AL E
S3AL IC
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S2IC C
S3IC C
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S3OW
S3IC
S4IC
S4OW C
S3IC
S3E
S3OW
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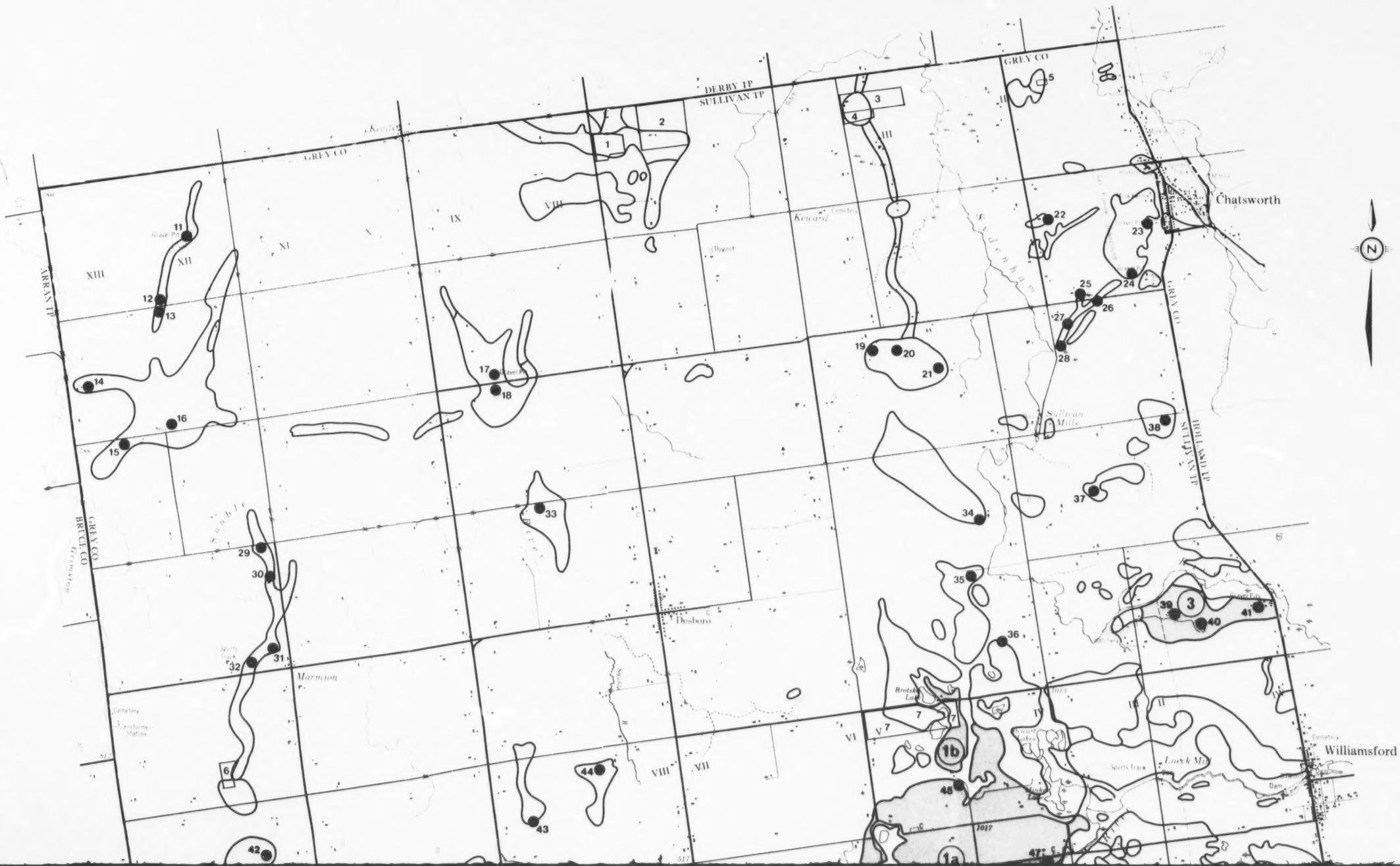
S3E
S3OW
S3IC
S3E
S3OW

Desboro
Williamsford
Lucky Mile
Dam
Cemetery
Dugout
Harrison L.
Auto Wreckers
Dornoch
Lake Eugenia
McClintock Lake
Lake Sarah
Lake Susan
Lake Mary
Lake Ann
Lake Lucy
Lake Jane
Lake Ellen
Lake Alice
Lake Helen
Lake Nellie
Lake Agnes
Lake Edith
Lake Grace
Lake Irene
Lake Ruth
Lake Dorothy
Lake Mabel
Lake Gertrude
Lake Florence
Lake Clara
Lake Bertha
Lake Hazel
Lake Pearl
Lake Opal
Lake Ivy
Lake Rose
Lake Violet
Lake Daisy
Lake Lily
Lake Iris
Lake Fern
Lake Moss
Lake Reed
Lake Sedge
Lake Willow
Lake Birch
Lake Maple
Lake Oak
Lake Pine
Lake Spruce
Lake Cedar
Lake Hemlock
Lake Tamarack
Lake Juniper
Lake Sequoia
Lake Redwood
Lake Sequoia
Lake Redwood
Lake Sequoia
Lake Redwood


GREY CO
DERBY TP
SULLIVAN TP
GREY CO
Chatsworth
ARRAN TP
GREY CO
BRUCE CO
Desboro
Marmion
Williamsford
HOLLAND TP
SULLIVAN TP
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1b
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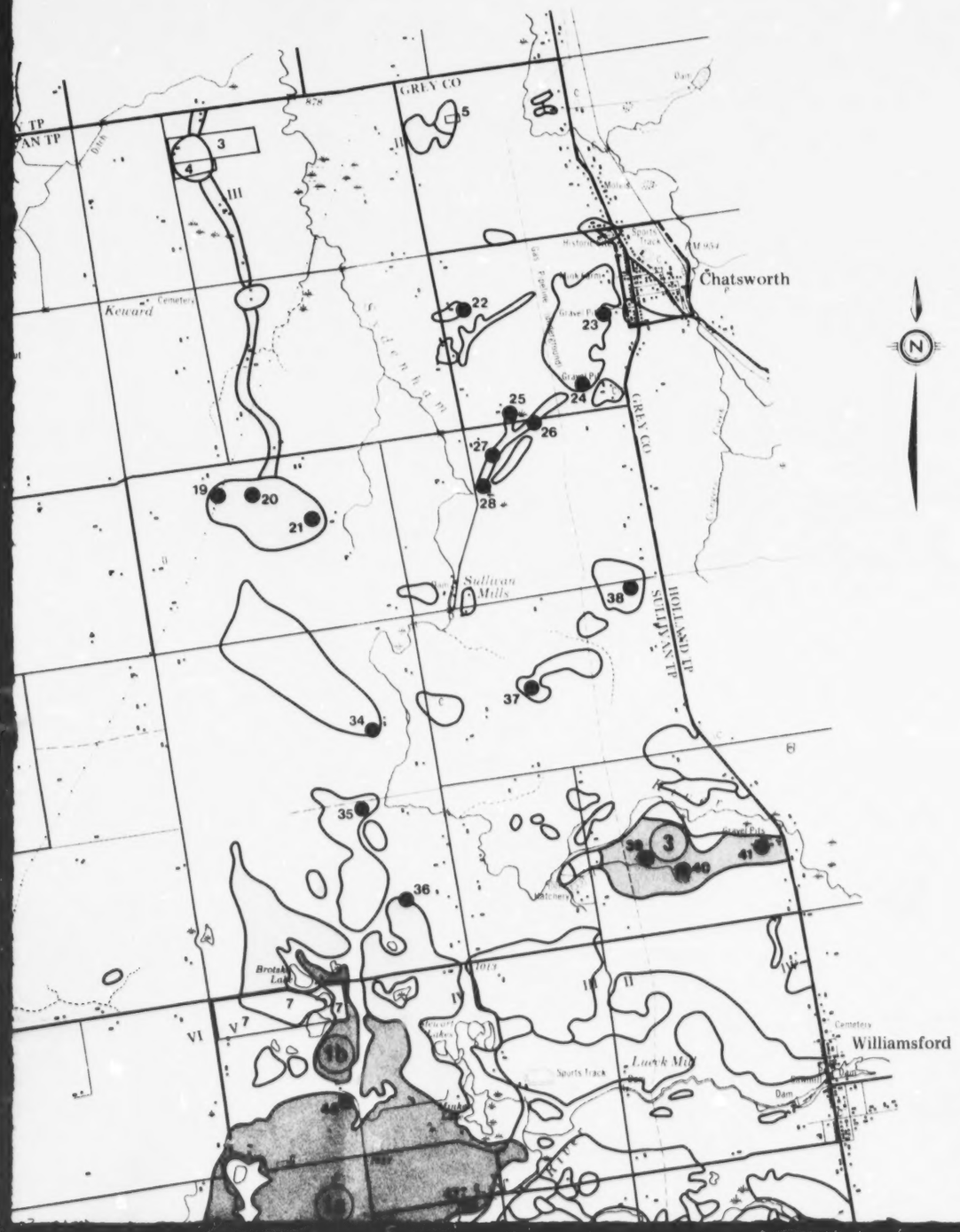

Ministry of Natural Resources

Ontario

Hon. Michael Harris
Minister

Mary Mogford
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

SULLIVAN TOWNSHIP

GREY COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/6, 41 A/7

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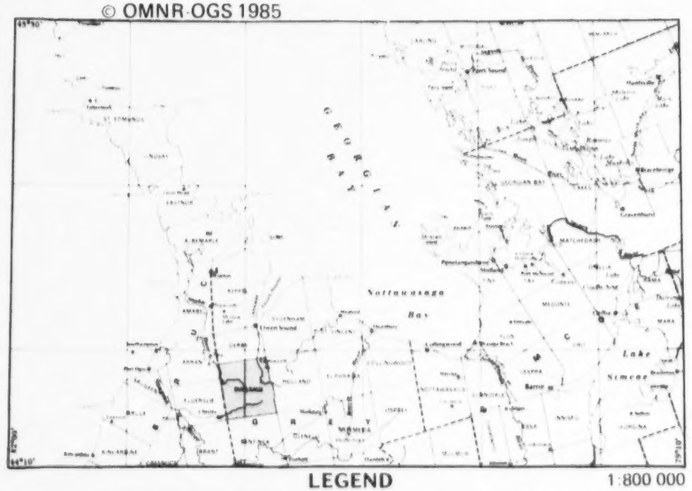


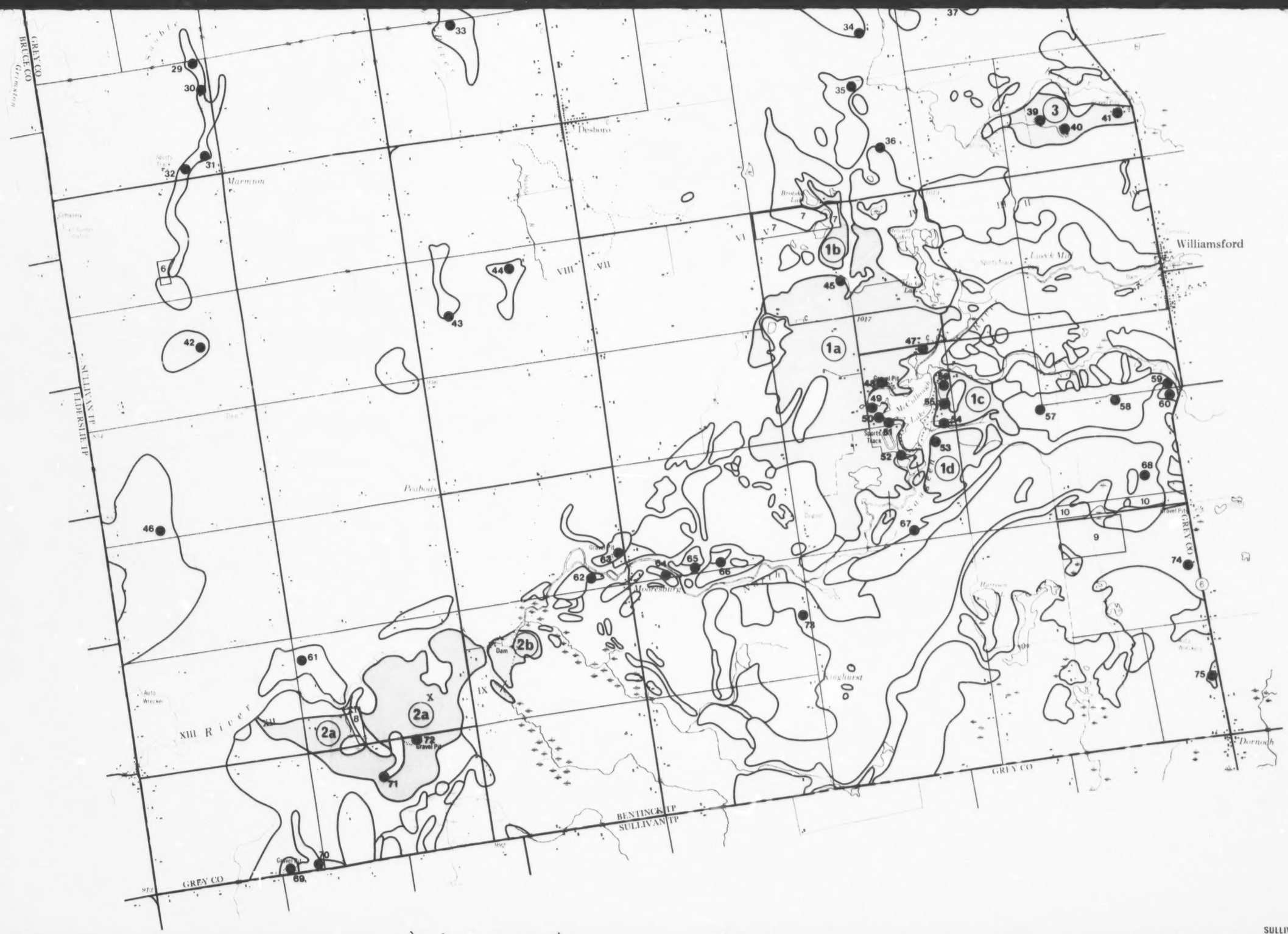
1:800 000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

(1)	Selected sand and gravel resource area, primary significance; deposit number; see Table 3.
	Selected sand and gravel resource area, secondary significance.
	Selected sand and gravel resource area, tertiary significance.


GREY CO
BRUCE CO
Desboro
Marmion
Williamsford
SULLIVAN TP
ELDERSLIE TP
Peabody
Dam
XIII River
BENTINCK TP
SULLIVAN TP
GREY CO
Dornoch
1a
1b
1c
1d
2a
2b
3
SULLIVAN

SULLIVAN

1 800 000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

(1) Selected sand and gravel resource area, primary significance; deposit number; see Table 3.

Selected sand and gravel resource area, secondary significance.

Selected sand and gravel resource area, tertiary significance

SYMBOLS

Geological and aggregate thickness boundary of sand and gravel deposits.

Municipal boundary

2 Licenced property boundary; Property number: see Table 2.

● 3 Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

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Issued 1985.

LEGEND

(continued from right margin)

SYMBOLS

(1)	Selected bedrock resource area; deposit number; see Table 6.
	Geological formation boundary.
	Geological formation member boundary.
	Formation thickness boundary (see text).
25	Drift thickness contour. (3-foot, 25 foot and 50 foot contours are shown).
	Municipal boundary.
Q2	Licenced quarry boundary; Property number: see Table 5.
● Q3	Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
X	Isolated bedrock outcrop.
O 24	Selected water well location; reported depth to bedrock (in feet).

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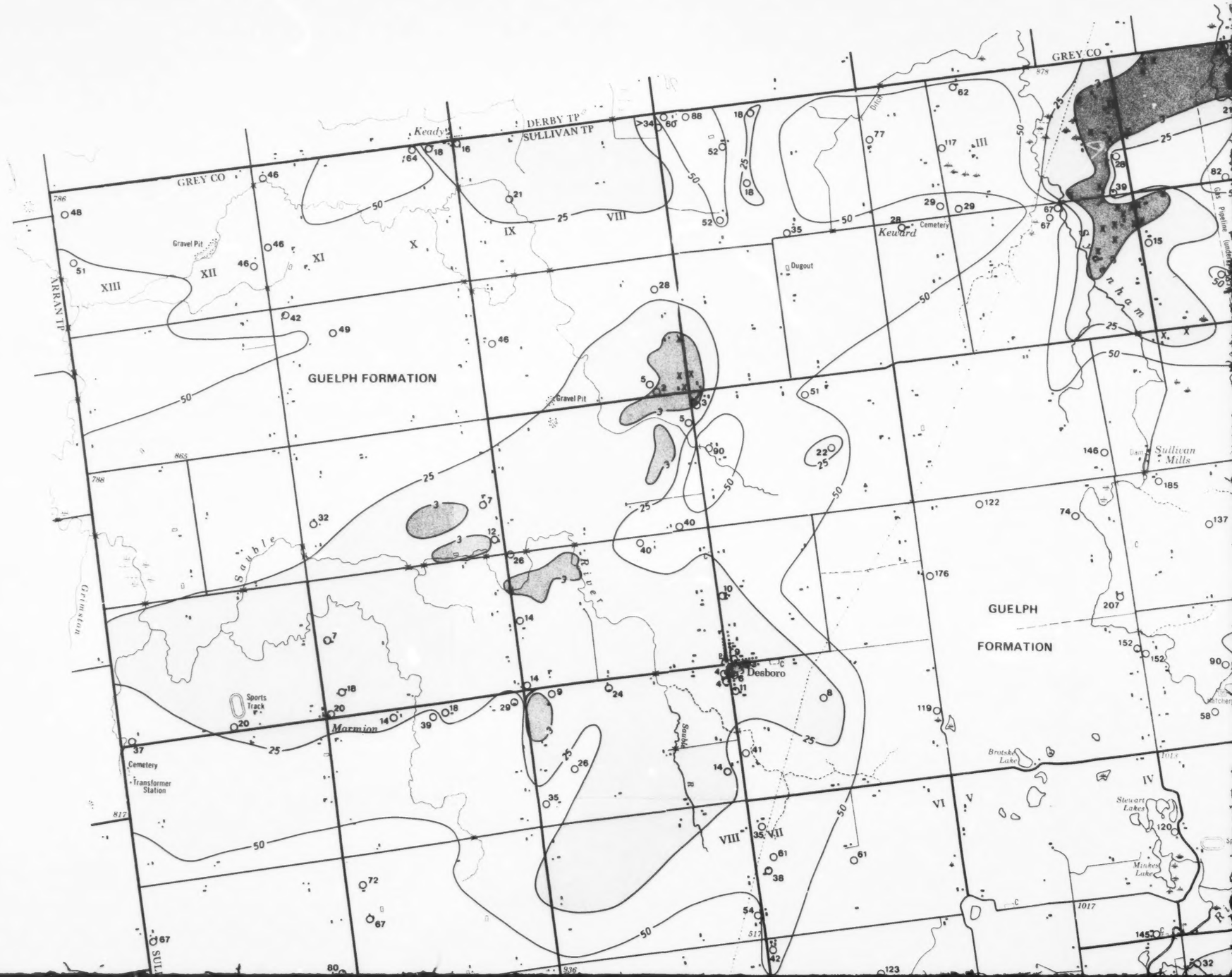

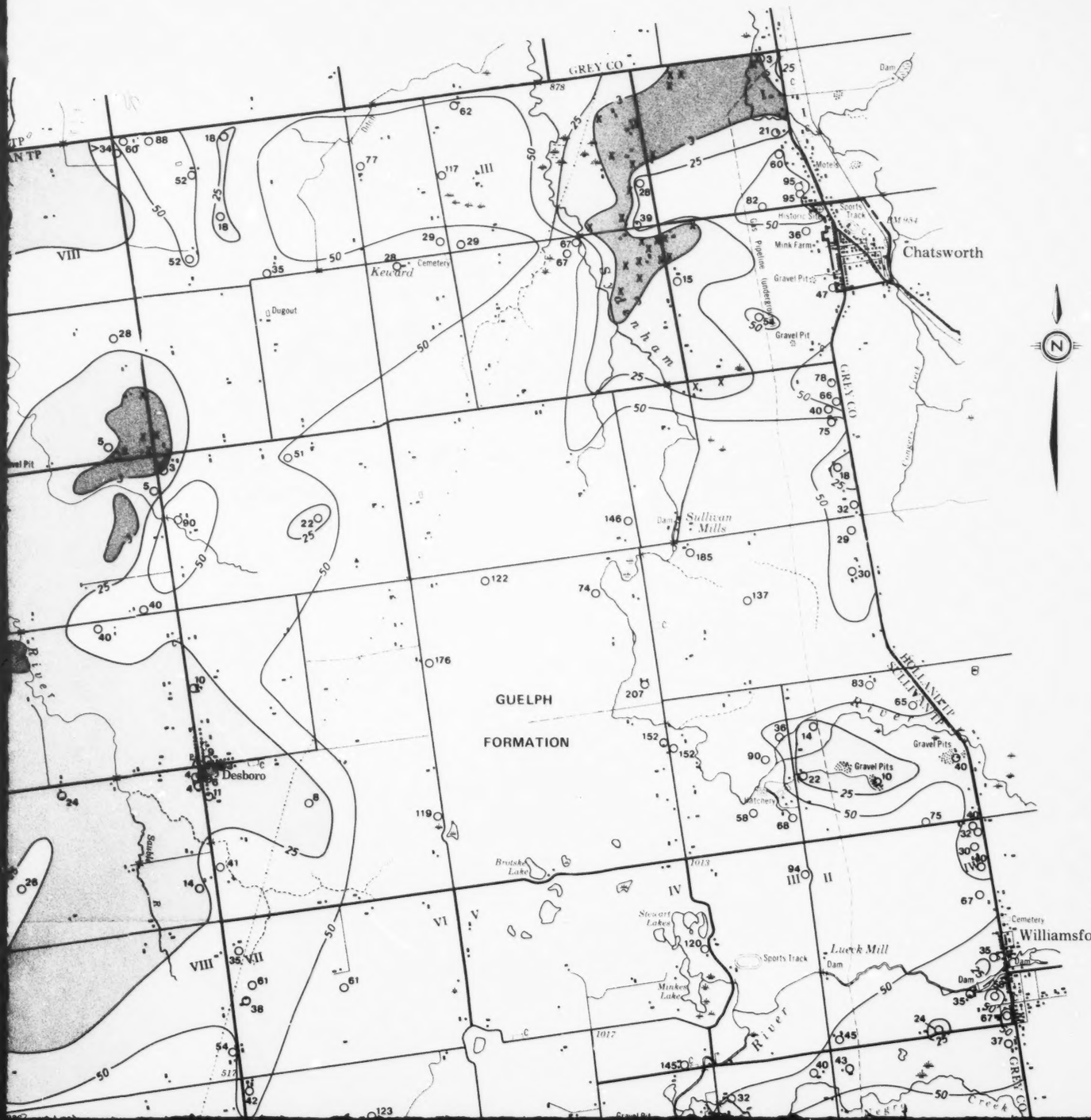

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ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

SULLIVAN TOWNSHIP

GREY COUNTY

MAP 3
BEDROCK RESOURCES

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/6, 41 A/7

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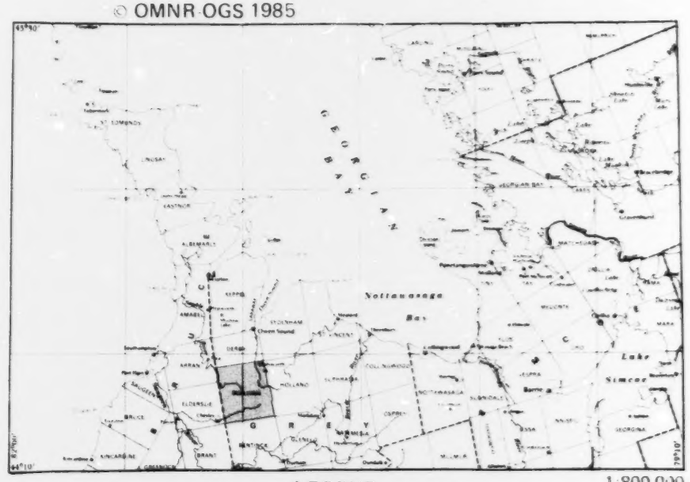

1:800 000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

SILURIAN

UPPER SILURIAN

SALINA FORMATION

Dolostone, shale, gypsum, salt

MIDDLE SILURIAN

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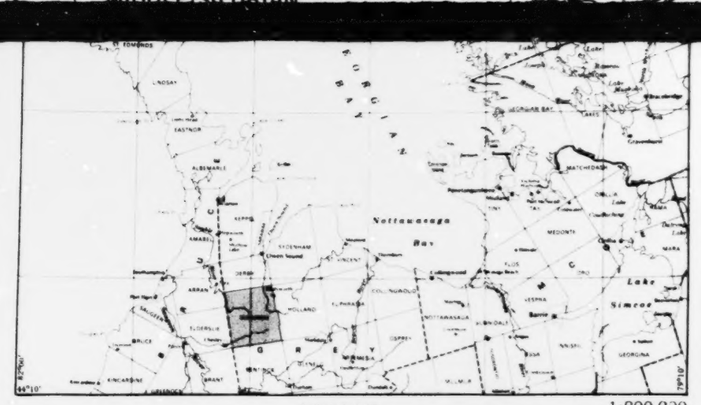
GUELPH FORMATION

GUELPH FORMATION



1:800 000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

SILURIAN

UPPER SILURIAN

SALINA FORMATION

Dolostone, shale, gypsum, salt

MIDDLE SILURIAN

GUELPH FORMATION

Dolostone

DRIFT THICKNESS

Bedrock outcrop (see Table 4); areas of exposed bedrock partially covered by a thin veneer of drift. Drift thickness is generally less than 3 feet (1 m).

Bedrock covered by drift (see Table 4); drift thickness is generally 3 to 25 feet (1 to 8 m). Bedrock outcrops may occur.

Bedrock covered by drift (see Table 4); drift thickness is generally 25 to 50 feet (8 to 15 m). Isolated bedrock outcrops may occur.

Bedrock covered by drift; drift thickness is generally greater than 50 feet (15 m).

(continued at left margin)

SULLIVAN